RECORDS

OF THE

GEOLOGICAL SURVEY

OF

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Part 1.] 1879. [February.

Annual Report of the Geological Survey of India, and of the Geological Museum, Calcutta, for the year 1878.

In the report for a year that has been comparatively unproductive of fresh work, I have to record, as compensation, the completion of the Manual of the Geology of India. The two facts are, indeed, closely connected: The Manual is principally—readers will often find cause to regret that it is not all—the work of Mr. Blanford, who was thereby prevented from taking the field in the open season of 1877-78. When results are to be measured by the knowledge gained from the study of obscure facts, many circumstances affect the tale of progress, which depends more upon the study than upon the accumulation of what are called observations. Geology has suffered much from the delusion that the two offices can be separated.

The Manual itself is a progress report *in extenso*—a full summary both of what is known and of what we fancy to be known regarding the geology of India, *i.e.*; of supposed (partial) facts, and of the apparent conclusions therefrom. Despite explanation and cautions given, students are likely to forget the very scanty and crude state of the information upon which much of the work is based, and therefore how liable to overthrow are the inferences suggested from that information. Such inferences have been freely offered in the Manual, in order to give point to the description, and to incite other observers with the agreeable encouragement of discovering error. Now that a more intelligent understanding is gaining ground regarding scientific method, the rational use of hypothesis as opposed to dogma, it is possible to be instructive without misleading others or stultifying one's self. Unfortunately, our work in India still suffers from the impunity with which either blunder might be committed; as the business of correction and exposure is almost entirely in our own hands. The duty of self-correction will not, however, be lost sight of, or evaded. The Manual affords an excellent datum-line, available to all, from which to mark the phases of our progress, and the annual report is the appropriate medium for bringing to notice such changes as have become necessary in the provisional interpretations of that date. Already, almost cotemporaneously with the publication of the Manual, the balance of evidence on some points has been affected by the results of the last season's work, as will be mentioned in the following remarks.

Before alluding to this work of detail, I would make mention of some general observations on the geology of India published within the year, and based upon the work of the Survey. Our distinguished colleague, Dr. Waagen, whose services, I am happy to say, are still engaged in our behalf, so far as his health will permit, presented to the Academy of Vienna a sketch of the geology of India based upon a discussion of its palæontology. Work of this kind is of the highest value and interest, as representing the results and the rationale of the details of palæontological research. For the benefit of English students, in India or elsewhere, a translation of the paper is published in the Records for November.

So far as relates immediately to India, the features evolved are of permanent importance. The only misgiving that occurs to one in respect of the wider generalizations is, that the provisional condition of the biological principles upon which most of these deductions depend may not have been sufficiently kept in view. Several relations in the comparative palæogeography of very distant countries are confidently assigned, on the assumption of certain laws of distribution of life, in time and space. Now, however confident we may feel regarding the general principle of the derivation of organic forms, the particular view of that principle necessary to the validity of such speculations as those under notice is still under discussion, and the familiar application of it, as if established, may (or even must) seriously interfere with the verification and study of the great biological problem which is the highest object of geological pursuit, and as subsidiary to which these geographical puzzles are principally of any interest. To those who are awake to the importance of the vital question, even though they may not be qualified to discuss it directly, such interference is a subject of regret.

In the last presidential address to the Geological Society of London, Professor Martin Duncan gives a most instructive review of many complicated problems in zoology and palæontology. From his statement of the objections to accepting the relative classification of the tertiary rocks of India, as recently put forward by the Survey, it might be thought that some decidedly unscientific prejudice had had influence in the discussion. Objections are of more service to us than approval, and some of those made by this high authority may not be so easily removed as the one I have mentioned. With the greatest respect for the work of the illustrious Falconer, of whom we are most justly proud as the local founder of palæontological research, it was not thought that his views could be final, or that they were compatible with a fuller knowledge of the formations. He had treated as one fauna the fossils from a prodigious series of strata, in which those fossils are by no means promiscuously distributed. It did not seem even that Falconer himself had considered his opinion conclusive on these points of correlation, more especially as regards the older gravels of the Indian river valleys.

When, therefore, a stone implement was found in these gravels, it was made the occasion of a special consideration of some features of the case that had not previously been discussed. This proceeding was no more than was demanded by the peculiar interest of the occasion. The same judicious caution has markedly characterized the most recent investigations by perfectly impartial observers regarding the human period in England.

Peninsular area: Azoic rocks.—To follow the order observed in the Manual, the azoic rocks are noticed first. The Arvali region is the only ground where we have been especially engaged upon these formations during the past season. Mr. Hacket examined a very large area at the northern extremity of the range, with all the outliers between Deeg and Toshám (near Hánsi), up to the Jumna at Delhi. Mr. Hacket has hitherto had this area all to himself, and at pages 48 to 52 of the Manual an abstract is given of the provisional views then suggested. Very considerable changes in the stratigraphical series are now proposed. The Mandan and Ajabgarh groups, lying mainly to the west of the Alwar and Delhi range of quartzites, were placed at the top of the series. The Mandan rocks occur in isolated ridges, and were separated from the Ajabgarh beds on account of the absence of certain bands that are prominent in the latter group; while the Ajabgarh beds were placed above the Alwar quartzites on account of some cases of steep, partial superposition which must now be regarded as inversions, for Mr. Hacket considers both the Mandan and Ajabgarh beds to be representative of the Raiálo group, underlying the Alwar quartzites. In the study of extensive areas of contorted transition rocks, the tendency is usually towards a greater subdivision and expansion of the series, original features of unconformity being often disguised by the crushing of the strata; but Mr. Hacket makes out a good case for this contraction of the Arvali series, as first proposed. The very mixed and variable character of the deposits of the Raiálo group was pointed out from the first; and in this as well as in other petrological characters the agreement of the Mandan and Ajabgarh rocks is sufficiently close, besides that new sections have shown these to have the same relation as the Raiálos to the gneiss and to the Alwar quartzites.

The adoption of two instead of four groups is, so far, an apparent simplification; but the chief structural difficulties of the ground are still unexplained. These are, the almost incompatible variations in the relations of these groups to each other and to the gneiss. In many sections the two groups are described as completely transitional, by interstratification. Again, each group is locally described as transitional with the gneiss: the Raiálo black slates passing down into a dark schistose gneiss; and the Alwar quartzites being transitional downwards with a gneiss that is only a subfoliated felspathic quartzite. But in other sections the Alwar quartzite is described as overlapping on gneiss, as in the hills between Udepur and Khandela, 40 miles north-west of Jeypore. These discrepancies might be got over by assuming that all the gneiss is simply converted Arvali strata, the metamorphism having extended locally to different horizons; and that the word 'overlap' is misapplied in such cases, for it implies a primitive gneiss, with original local absence of the Raiálo group; and no distinction of gneisses has been attempted. This easy solution of the difficulty might be adopted, were it not that other observations independently require such original conditions as are implied by overlap: in the little hills south of the railway between the Basi and Jatwára stations, 20 miles east of Jeypore, a coarse conglomerate occurs at the junction of the Alwar and Raiálo groups, containing large boulders of gneiss, quartzite, limestone, and of a banded jaspideous rock, in a schistose matrix. Now, it seems impossible, under any recognized doctrines of rock-formation, to consider such debris as this to be derived from the series in which it occurs; and the gneiss boulders especially require the supposition of a metamorphic series older than that of the Arvalis themselves, and upon which an overlap of the Alwar quartzites might naturally occur. But no such rocks have been discriminated within the very large area of these formations explored. Should this stratigraphical evidence fail, it may be permissible to suggest some primitive conditions of rock-formation, involving some very rapid process of induration of deposits, or even their crystallization, to take the place of what is commonly implied by metamorphism; and also involving much greater facilities of very local disturbance, whereby the same deposits may be strongly unconformable and in unbroken sequence, within close proximity. The proved extreme antiquity of the transition rocks of the Indian Peninsula admits, perhaps, of some appeal to conditions differing widely from any standard of processes now in operation. These rocks may, indeed, be azoic in the original acceptation of the term—anterior to the appearance of life in this portion of the earth's surface.

The foregoing remarks refer only to the Arvali rocks, as hitherto described; but Mr. Hacket's observations of last season lead him to extend these views to some rocks of the adjoining region to the east, although without a re-examination of these sections. The change offers an immediate relief from the difficulties stated on pages 51 and 52 of the Manual. At the eastern edge of the Arvali region, close along the scarp of the Vindhyan series, there appear in the Hindaun ridge some typical representatives of the Gwalior series. In their standard area, to the east of the Vindhyan basin, these rocks rest, undisturbed and completely unconformable, upon the gneiss of Bundelkhand; and the puzzle was to find a place for these Gwaliors of the Hindaun ridge, either between the Vindhyans and the Arvali series, or between these and the Arvali gneiss; the former alternative being provisionally accepted as the least anomalous. It was thought that the peculiar composition of the Gwalior rocks and their local unconformity to the Arvali series forbade their being identified with this series. Now, however, Mr. Hacket considers that, as with the Mandan and Ajabgarh groups, so the Gwalior rocks must be brought within the horizon of the Raiálo group, and for similar reasons. The most peculiar and prevailing character of the Gwalior series is the presence of jaspideous bands, generally of a bright red colour. The very special nature of this rock, however abundant locally, would be in itself an excuse for not insisting upon it as a character of wide extension. The objection is, moreover, modified by the occurrence of compact silicious bands in the Raiálo group, as in the hills near Sathána in Shaikhawáti; near Chenpura, north-east of Basi railway station; and near Muhammadpur, south of Kherli station.

The Gwalior rocks have been independently ranked as in the upper transition series of Peninsular India, as probably equivalent to the Kadapah series of Southern India; and thus the Arvali series, in great part metamorphic, would be brought into a more defined position in the general scale of Indian formations.

Gondwána rocks: Palamow.—On page 198 of the Manual mere mention could be made of the 'unsurveyed basins of Palamow.' A description of these coal-fields by Mr. Ball, with maps, has since been published (Mem. G. S. I., Vol. XV, pt. 1). This ground is more accessible from the trunk railway than the coal-basins of the upper Damuda valley; and projects for working the coal have lately been proposed. Two new coal-fields have been marked in the basin of the Koel river: the Aurunga field on the east has an area of 97 square miles; and the Hutár field on the west, traversed by the river Koel, has an area of 78 square miles. Both measurements include the whole of the Gondwána deposits, but the areas to be deducted from the Talchir outcrop are small. So far as could be determined from surface indications, the coal of these areas, especially in the Aurunga field, is not so good as that of the smaller Daltonganj field, lower down the Koel, to the north.

The geological interest of this ground is, that here a marked change takes place in the petrological characters of the Gondwána system, between the series as developed in the Damuda valley coal-fields and that found in the great midland area of South Rewah (the Son region), as well as in the Mahánadi and Godávari regions. In the Damuda region three considerable deposits (the Ironstone Shales, Rániganj, and Panchet groups), of lower Gondwána age, are petrologically well distinguished from the lower coal-measures (*Barákar group*). These groups are here overlaid by a thick sandstone, generally characterized by its comparative want of earthy bond, and its consequent porosity. It was originally named the upper Panchet group, in the Rániganj field; but from its presumable equivalence to the Dubrájpur sandstone of the Rájmahál region, in which upper Gondwána fossils occur, and from partial unconformity, it has latterly been separated from the lower Gondwána series, under the general name 'Mahádeva,' which is at present a partial equivalent for upper Gondwána. In the midland and south-eastern regions a sandstone of this type rests immediately upon beds representing the lower coal-measures of Bengal, and overlap-unconformity is at many places very marked at this horizon. Notwithstanding these marks of changed conditions, it appears from the fossils that a great thickness of these upper sandstones (Kámthis) in the Godávari valley must be recognized as lower Gondwánas, possibly on the horizon of the Rániganj group of the Damuda fields.

Mr. Ball established the same fact for the upper sandstones at Hengir in the Mahánadi region; and he now (*l. c.*, p. 46) confirms the observation of the strong resemblance between that rock and the sandstone resting on the lower coal-measures in Western Palamow, but which he shows to be unquestionably identical stratigraphically with the supra-Panchet sandstone of the Damuda area. Upon this the suggestion is made that the Hengir rocks present a blending of the characteristics of two groups, which in Palamow are separated by a distinct interval. Of such distinct interval, however, no more direct stratigraphical evidence is found in Palamow than elsewhere, beyond the original fact of the intercalation of deposits not found away from the Damuda area: the apparent sequence of the upper sandstone (Mahádevas of Mr. Ball's report) on the Barákars here being at least as regular as in the south-eastern Gondwána regions; so that the expectation to find lower Gondwána fossils in this rock here would still be justified. Thus, the question stands pretty much as before, save that we know exactly where this change of petrological characters takes place.

It had been surmised that this change would coincide with the limits of the Damuda valley; but Mr. Ball has found that it is not so. A barrier of gneiss, between the Kárunpura and Aurunga coal-basins, divides the waters of the Damuda and the Aurunga, which is a tributary of the Koel; and in the eastern part of the Aurunga field the Panchet and Rániganj groups are about as well developed as in the Kárunpura field, their combined thickness being about 1,700 feet, and they are covered by the upper sandstone. Notwithstanding this great development in thickness, the extension of these two lower Gondwána groups is strangely limited. The feature under notice is, indeed, brought within a compass of two miles in the hills south of Latehár, at the west end of which the upper (Mahádeva) sandstone rests on Barákars, and at the east end on Panchets. Both the north and south boundaries are represented as faulted, so that the overlap cannot be followed out; but this case gives at least the assurance that the covering sandstone, so differently circumstanced at its base, is one and the same formation. The absence of fossils in these sections is deplorable. Without them the position of this top sandstone in the general series must remain doubtful: in the west of the Aurunga field its relation to the coal-measures is precisely like that of the Kámthi and Hengir rocks to the similar coal-measures of the Godávari and Mahánadi regions, while in the eastern part of the field it overlies beds (Panchets), which in turn overlie those (Rániganj) that have been correlated with the Kámthis.

The gneissic barrier between the Aurunga and Kárunpura fields being much higher relatively to the former than to the latter, Mr. Ball considers that the separation is due to disturbance, by a sinking of the Aurunga basin; so that they may still be virtually considered as belonging to the same original area, and the similarity of the sections be attributed to some peculiar conditions of that ground.

In the Son region, shortly to the west of Palamow, the upper sandstone series becomes enormously expanded; and if, as seems probable, this rock in Palamow represents the base of that expanded series, which, again, in its southern extension is likely to be identified with the Kámthi beds of Hengir, then the top sandstone of the Damuda region cannot properly be classed as upper Gondwána (Mahádeva), or identified with the Dubrájpur group of the Rájmahál region; nor could the Kámthis then be properly correlated with the Rániganj group, unless a certain correspondence of the fossil floras at distant localities is to set aside local superposition in the Damuda region, represented elsewhere by the most clearly and most widely marked stratigraphical change in the whole Gondwána series.

It is independently a most puzzling circumstance, how such great overlap, as that described within the sedimentary series in the Aurunga basin, can be attended by so little evidence of unconformity in adjoining ground. Mr. Ball's supposition that much disturbance and denudation, whereby the chain of coal-basins of the Damuda valley were defined, and whereby the deposition of the upper sandstone was limited to that depression, intervened before the deposition of the upper sandstone, almost increases the difficulties of the case in the absence of any evidence for such unconformity as must have attended that event.

The most distinct case of apparent disturbance-unconformity observed by Mr. Ball (*l. c.*, p. 87) is between the upper sandstone and the Panchets, not between it and the lower coal-measures. It is still an open question whether the apparent anomalies of these sections may not be largely traced to original (pre-Gondwána) conditions of the surface.

Godávari region.—From the foregoing remarks it will be understood that the distinction of upper and lower Gondwána rocks in the Damuda region is still presumptive, based principally on the supposed equivalence of the top sandstone of the series with the undoubted upper Gondwána sandstone of the detached area to the north-east, in the Rajmahál hills, and upon occasional cases of overlap-unconformity in the Damuda coal-fields. But similar unconformity and great irregularity occurs also in the upper groups of the recognized lower Gondwánas of the Damuda region; while the most marked lithological change and overlap-unconformity in the midland and southern Gondwána regions is found within the lower Gondwána series, between the coal-measures and the Kámthi-Hengir sandstones, which in this direction present the most marked analogue of the top sandstone of Palamow.

In the Godávari region the fixing of this middle Gondwána horizon has been for some time, and is still, a great puzzle. On the lower Godávari it seemed to be made out by Mr. King, between the local representatives of the Kámthi group and the Golapilli sandstones, containing a Rájmahál flora; and Mr. King thought he identified this group on the Pránhita, just above its confluence with the Godávari, in the sandstone of Sironcha, having found Golapilli fossils in what he took to be a top band of this sandstone at Anáram, near Kota, not far below the well known *Lepidotus* limestone of that place (Rec. G. S. I., Vol. X, p. 55).

Working from the north, Mr. Hughes found no upper Gondwána rocks in the Wardha coal-basin, but at the southern edge of that area, on the lower Wardha, about Porsa, the Kámthis are overlaid by red clays, which are identified with the well known *Ceratodus* clays of Maleri. This formation spreads rapidly to the south. It is locally covered on the east by the plateau-forming conglomeratic sandstones of Chikiála, resting against Vindhyan rocks; and to the west it extends far up the Jangaon valley, gradually overlapping the Kámthi strata, so as to rest against Vindhyans, and then passes under the Deccan trap. Here, too, plant fossils of decided upper Gondwána type were found, so that on this cross-section the whole Gondwána area, 50 miles wide, is occupied by well marked upper Gondwána strata. South of the Jangaon valley the Kámthis emerge again in force, encroaching upon the upper rocks up to Sironcha, where the latter are reduced to a width of six miles. Mr. Hughes carried his lines up to the Godávari and the Pránhita at Sironcha, recognizing no group between the Kota-Maleris and the Kámthis. Here he encountered Mr. King's Sironcha sandstone, the lithological peculiarities of which he admits, considering it more like the rocks associated with the Maleri clays, than it is like the typical Kámthis (Rec. G. S. I., Vol. XI, p. 23). If, however, this rock, as mapped by Mr. King up to the Godávari from the south, is to be taken in this light, or as a group distinct from both Maleris and Kámthis, or, as would appear on Mr. Hughes' map, in great part as a peculiar form of the upper Kámthis, a part of the ground mapped north of the Godávari will have to be modified accordingly.

Mr. King's observations of last season are still conflicting as to which of these views may prove true. He finds the conglomeratic sandstone of Anáram, with which the upper Gondwána fossils occur, to be local, and considers it more likely to be a local deposit, or a remnant of an overlying formation, than to belong to the underlying Sironcha sandstone. Again, he describes regular Sironcha sandstone as unconformably overlaid by the reptilian clays of the Agrezpali outlier, on the Godávari, 16 miles above Sironcha. Mr. Hughes thought these clays might be high in the Kota-Maleri group; but Mr. King does not adopt this suggestion, and considers them on the horizon of the beds at Maleri. Thus, these two observations are strongly suggestive of the Sironcha being lower Gondwána, either as upper Kámthis, or as an independent group.

On the other hand, Mr. King is in favour of a division of the Kota-Maleri group, as he finds that its upper portion only, at and above the horizon of the Kota limestone, is represented in the prolongation of that formation south-east of the Pránhita, overlying, if not faulted against, the Sironcha sandstone. Such an overlap would be valid ground for reviving the original question of the probably marked separation of the *Lepidotus* limestone and the *Ceratodus* clays. In this connexion Mr. Hughes' partial identification of the Sironcha sandstone with that associated with the Maleri clay (Rec. G. S. I., Vol. XI, p. 23) is suggestive of the possibility that these two rocks are locally representatives of each other. In this case the views given in the preceding paragraph would require modification: the search for the middle Gondwána horizon would have to be taken up again, even in the Kota-Maleri area; involving the reinvestigation of the horizon of the plant beds in the Jangaon valley, as to whether they may not be in the upper division of the group, as is indeed suggested by the probable identification of the Chikiála beds at Balánpur. Mr. King hopes to be able to revise, and decide upon, these crucial points during the present season.

Early in the season Dr. Feistmantel visited the Sátpura coal-basin, to examine on the ground some good sections of the Gondwána series, the flora of which he has been studying and describing so carefully, and with great advantage to the Survey. The coal-measures of those fields were always taken to represent Barákars, the lowest of the Damúda coal-measures; and Dr. Feistmantel has shown that they belong rather to that still lower horizon of coal-bearing strata, represented by the Karharbári measures in Bengal.

On the western confines of the Peninsula, where the Gondwánas become associated with marine strata, Mr. Fedden broke new ground in Kattywar. He was detained by office work in Calcutta, in classifying some of the collections made by him in previous years, and arranging them in the new Museum, and he consequently did not take the field till the end of 1877. In the early months of the past year he surveyed a portion of Kattywar, amounting to about 1,800 square miles, comprised in Topographical Survey sheets 21, 22, 23, and portions of some of those adjoining. Mr. Fedden speaks very highly of the excellence of these maps. The country examined is for the most part flat, and the rocks consist of Deccan traps, overlying sandstone, in which some remains of plants were found. These plants prove to be identical with those occurring in the uppermost jurassic or Umia beds of Cutch, and it is thus clear that a portion at least of the Cutch jurassic series extends into Northern Kattywar.

The greater part of the area examined consists of jurassic sandstone, the hills being of trap; but to the southward, where the surface is more hilly, the traps cover the country. The beds, both of sandstone and trap, are nearly horizontal. In some places between the jurassic beds and the traps a thin band of limestone is found, which contains a few obscure marine organisms. This band may perhaps represent the Bágh beds of the Narbada valley. A few intertrappean bands are found, and some outlying patches of milliolite were noticed resting on the trap.

In Southern India Mr. Foote took up new ground to the south of Trichinopoly. In crossing the cretaceous area he made some valuable additions to our fossil collections from those formations. He also re-examined the localities where the Utatúr plant beds occur at the base of the series. He completely identifies them with the jurassic beds containing both plants and marine animal remains, described by himself, at many points along the coastal region up to the Kistna. From the entire similarity of the fossil plants and their mode of preservation to those of the deposits elsewhere in which marine fossils are described in the same beds, Mr. Foote is of opinion that the Utatúr plant beds also are probably marine; in support of which view he mentions his inability to find stratigraphical evidence (more than overlap) of a break between them and the overlying middle cretaceous deposits, thus confirming the previous observation of others upon this interesting point. Mr. Foote's notes upon these features are published in the Records for the year.

The country south of Tanjore has, so far, proved very uninteresting; no rock appearing between the gneiss and the coast alluvium, except the Cuddalore sandstone formation, intimately blended with the covering laterite.

Extra Peninsular area.—In the extreme North-Western Punjab, Mr. Wynne made a preliminary examination of some new ground in Hazára, having been prevented by difficulties on the frontier from following the formations of the Salt Range across the Indus into Bannu, as had been proposed. Owing to the exceptionally wet season, and illness occasioned thereby, the amount and details of the work are not what Mr. Wynne expected to accomplish; still he has given a most useful reconnoissance of the ground: the limits of the crystalline rocks forming the higher mountains have been defined, and a tentative classification and distribution given of the unaltered sedimentary series to the south of the gneissic area.

The most interesting feature of the observations is the extension to the older rock-series of the contrast which has been known to exist in the newer formations, between the Southern Himalayan area and the country to the west of the Jhelam. In Huzára the rocks adjoining, and apparently in sequence with, the gneissic rocks are a great thickness of sandstones, quartzites, and dolomites, called by Mr. Wynne the 'Tanól series,' presenting little or no correspondence with the strata similarly related to the gneiss of the Pír Panjál. But the most anomalous circumstance is, that Mr. Wynne provisionally identifies the Tanól series with the 'Infra Trias' group of the section in Sirban mountain (west of Abbottabad), which is there distinctly in unconformable superposition on the Attock slates (*see* Manual, p. 499), this relation not being so clearly defined at the junction of these slates with the main area of Tanóls, west of Abbottabad. If these conjectures are confirmed, it would seem that the gneiss of Hazára is much newer than the central gneiss of the Himalayas.

The severe famine in Kashmir interfered much with Mr. Lydekker's work in the North-West Himalayas. This, and a temporary indisposition, prevented his carrying out his projected trip to the Gilgit region; so he spent the season in the mountains of Drás and Tilail, where he has described some important sections of the sedimentary rocks. Mr. Lydekker insists strongly upon the transitional relations of the whole series from silurian to upper triassic (*see* Manual, p. 660).

Colonel McMahon has again made an important contribution to our work in the Himalayan regions—this time in the Central Himalayan districts, to the north of the Simla region of the lower Himalayas. His observations involve a reconsideration of some views provisionally put forward in the Manual, while yielding confirmatory evidence upon others.

The strongly unconformable relation of the limestone and slate series of the lower Himalayas to the central gneiss, presented some difficulty as compared with the pseudo-conformity of the same sedimentary series to this gneiss on the Tibetan side (Manual, p. 679 (*a*)). Colonel McMahon describes this northern junction within four miles of the intrusive granitic mass of Gongra, between Lipe and the Ruhang Pass, as exhibiting an appearance of transitional metamorphism, which contrasts with the more abrupt contact at the Bhabeh Pass and in Niti. Such local action does not, however, disturb the inferences based upon the other sections. On the other hand, he observed in Hangrang, east of the lower Spiti valley, the upper (Muth) beds of the slate series to be in original superposition on gneiss at the base of the Porgyil Mountain, the gneiss being, up to the very contact, profusely cut up by large and small granite veins that do not penetrate the overlying limestone and slates, which are not described as more altered than at points remote from the crystalline rock. This would appear to fix a very definite limit as to the age of these granitic veins; and the total overlap of the great mass of the slate series establishes for this area original conditions of unconformity with the central gneiss, like those already exhibited in the Simla region. The position of this overlap, against the transverse gneissic mass of Purguil, shows, moreover, that this barrier between the Zánskár and Hundes basins is of very old standing, though it may not always (since palæozoic times) have been so prominent as now.

Another important observation of Colonel McMahon's is his reaffirmation of Stoliczka's original identification of the Krol limestone with the Lilang limestone of Spiti. This decided opinion, based upon immediate comparisons of the sections in those adjoining regions, although separated by the great gneissic axis, cannot be set aside; it is at least as valid as the very broken chain of evidence upon which a different correlation was provisionally adopted in the Manual (pp. 595-6). The intimate connexion of the triassic and carboniferous series, as urged by Mr. Lydekker, will, in the absence of fossils, make the close decision of this question a matter of greater difficulty.

Mr. Theobald made large additions during last season to our collections of the Siwalik fauna, the results of which are duly recorded, up to date, in Mr. Lydekker's papers in the Records and the Palæontologia Indica. Mr. Theobald is now engaged upon the tertiary zone east of the Ganges in Rohilkhand, at the base of the Himalayas of Garhwál and Kumaun.

Mr. Mallet was deputed in December to report upon some coal seams in Rámri Island, reported by the Commissioner of Akyab. Mr. Mallet could not form a favourable opinion of the practical value of these measures; the coal is inferior to that of Bengal, and the measures are greatly disturbed, and would be very difficult to work. Specimens of a very different coal, a bright jetty lignite, were forwarded by the Commissioner from the Baránga Islands. The site of this coal has not yet been discovered; but the fact that the piece sent is distinctly a piece of carbonized wood, suggests the probability that it occurs in isolated logs, and not as a continuous seam. The petroleum of this region seems, so far, to offer more favourable prospects than the coal.

My own time was fully engaged throughout the greater part of the year in directing the work of the Survey, and in editing the publications, including the Manual. Without a fully qualified Assistant permanently at head-quarters to relieve me of some of these very important and responsible duties, it is most difficult for me to undertake effectively the more congenial occupation of examining crucial questions in the field. The cumbersome arrangements for camp life, and the slowness of moving about in this way, prevent any compensating results being obtained within much less time than a full season in the field. At the same time I feel that my long experience in field work is not used for the best advantage of the Survey unless as partially applied in that way.

In February I made a short trip to the North-West Provinces, to serve on the Committee appointed for investigating into the causes of deterioration of land by *reh* in the Aligarh district. I had many years ago made some partial observations on this subject; and I have been again strongly impressed with the extensive injury to cultivation to be apprehended from reh in connexion with canal irrigation in the excessive climate of North-Western India. My notes on the subject were submitted to the Committee, and published in its report.

I took the opportunity while in the neighbourhood to investigate two recent cases of supposed discovery of coal: one in the Siwaliks of Dehra, reported by the Railway Department, and one in the same rocks of Náhan, to which my attention had been called by the Punjab Government. From my pretty accurate acquaintance with this ground, I was fully satisfied that the reports were fallacious; but in regard to the importance of the subject, and to the general want of confidence in independent geological judgment, I visited both localities. The result was what I expected: it would have been impossible to extract one hundred-weight of coal from all that was left of the supposed "seams." The repeated revival of these oft exploded discoveries is one of the chronic evils of the perpetual change of staff in every office throughout India.

Publications.—Two principal Memoirs, expected to be issued within the year, have been unavoidably kept back. As explained in last year's report, the letter press and plates of Mr. Wynne's report on the Salt Range, forming Vol. XIV of the Memoirs, were then ready for issue, waiting for the colour-printing of the map. This has not yet been received. Fully coloured proofs have recently been passed for press, and the issue of the report cannot now be much delayed. The postponement of Mr. Blanford's Memoir on Sind has been already explained. Mr. Foote's Memoir on the Nellore District is in hand for publication. Thus the only number of the Memoirs actually issued during the year was Part 1 of Vol. XV, containing Mr. Ball's report (with three maps) on the Palamow coal-fields, of which a notice has already been given. By orders of Government, the price of these volumes has been considerably reduced.

THE RECORDS for 1878 are, by way of compensation, much more full of matter than usual, extending to three times the size originally contemplated, and containing numerous outline-maps.

Of the PALÆONTOLOGIA INDICA two large parts were issued during the year: one by Dr. Feistmantel on the flora of the Jabalpur group, containing 14 plates, and one by Mr. Lydekker on the crania of fossil Ruminants, containing 18 plates. Two other parts by the same authors are now in the press. A revision of the somewhat confused classification of these publications has been made, for publication on the covers, from this date. The price has also been reduced.

Museum.—So far as compatible with other current work, good progress has been made in the arrangement and labelling of the collections in the new cases by Dr. Feistmantel and Mr. Lydekker in the palæontological galleries, and by Mr. Mallet in the mineral gallery. The frequent calls on Mr. Mallet for occasional assays and analyses, form a serious but unavoidable interruption to the systematic examination he is making of the mineral products of India, so far as represented in our collections.

Library.—During the past year 950 volumes, or parts of volumes, have been added to the library: 462 by purchase, and 488 by presentation or in exchange. The new fittings in the library were completed within the year, so it will now be possible to complete the thorough arrangement of the books.

Personnel.—Mr. Hughes was absent on furlough for the whole year. Mr. Ball left on two years' furlough on the 1st of July. Mr. Lydekker was absent on privilege leave from 9th February to 8th of May; Dr. Feistmantel, from 21st of March to 20th of June; Mr. Mallet, from 2nd July to 19th of October; and Mr. King, from 27th July to 21st October.

I regret to have to record the death, on the 23rd March, of Mr. Walter Lindsay Willson, who joined the service in March 1857. He had then been for some years senior geologist on the Geological Survey of Ireland; and the training he had there received was very marked in the finished neatness of his field-maps in India.

Mr. Carl Ludolf Griesbach, F.G.S., was appointed by the Secretary of State in the room of Mr. Willson, and joined his post on the 11th November. Mr. Griesbach's acquaintance with the Karoo formation of South Africa will be of service in elucidating the supposed correspondence of those strata with the Gondwána series of India. He has accordingly been deputed to take up work for the present on these rocks in the Sone region, in continuation of Mr. Ball's survey of Palamow.

Apprentice Kishen Singh was on duty till November with Mr. Theobald, who reports favourably of his intelligence, zeal, and good conduct. Apprentice Hira Lal was on duty at head-quarters, where he performed useful service in the Museum under Mr. Mallet and Dr. Feistmantel. He was sent to the field with Mr. Griesbach in November, when Kishen Singh was recalled to take up the duties in the Museum.

H. B. MEDLICOTT,
Supdt. of the Geological Survey of India.

CALCUTTA,
January 1879.

List of Societies and other Institutions from which Publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1878.

AMSTERDAM.—Royal Society of Batavia.
BELFAST.—Natural History and Philosophical Society.
BERLIN.—German Geological Society.
" Royal Prussian Academy of Sciences.
BOMBAY.—Bombay Branch Royal Asiatic Society.
BOSTON.—American Academy of Arts and Sciences.
" Boston Society of Natural History.
BRESLAU.—Silesian Society of Natural History.
BRISTOL.—Bristol Museum.
" Naturalists' Society.

BRUSSELS.—Geological Society of Belgium.
„ Belgium Geographical Society.
BUDAPEST.—National Museum.
CALCUTTA.—Asiatic Society of Bengal.
„ Agricultural and Horticultural Society.
„ Meteorological Survey.
CAMBRIDGE (MASS).—Museum of Comparative Zoology.
CAPE TOWN.—Department of Crown Lands.
CINCINNATI.—Zoological Society.
COPENHAGEN.—Royal Danish Academy.
DAVENPORT.—Academy of Natural Sciences.
DIJON.—Academy of Sciences.
DRESDEN.—The Isis Society.
„ Kais. Leopol.-Carol. Deuts. Akademie.
DUBLIN.—Royal Geological Society of Ireland.
EDINBURGH.—Royal Society.
GENEVA.— Physical and Natural History Society.
GLASGOW.—Glasgow University.
GÖTTINGEN.—The Gottingen Society.
LAUSANNE.—Vaudois Society of Natural Science.
LIVERPOOL.—Geological Society of Liverpool.
„ Literary and Philosophical Society.
LONDON.—British Museum.
Geological Society of London.
Linnean Society of London.
Royal Geological Society of London.
Royal Institution of Great Britain.
Royal Society of London.
Zoological Society of London.
MADRID.—Geographical Society of Madrid.
MELBOURNE.—Mining Department, Victoria.
„ Royal Society of Victoria.
„ Geological Survey of Victoria.
MINNESOTA.—Geological Survey of Minnesota.
„ Academy of Natural Sciences.
MOSCOW.—Imperial Society of Naturalists.
MÜNICH.—Royal Bavarian Academy of Sciences.
NEW HAVEN.—Editors of the American Journal of Science.
PARIS.—Geological Society of France.
„ Mining Department.
PENZANCE.—Royal Geological Society of Cornwall.
PHILADELPHIA.—Academy of Natural Sciences.
„ American Philosophical Society.
„ Franklin Institute.
PISA.—Society of Natural Science, Tuscany.

PLYMOUTH.—Devonshire Association.
ROME.—Geological Commission of Italy.
" Royal Academy.
ROORKEE.—Thomason College of Civil Engineering.
SALEM. MASS.—American Association for the Advancement of Science.
" Essex Institute.
STOCKHOLM.—Royal Academy of Science.
ST. PETERSBURG.—Imperial Academy of Sciences.
SYDNEY.—Royal Society of New South Wales.
TASMANIA.—Royal Society.
TURIN.—Royal Academy of Sciences.
VIENNA.—Imperial Academy of Sciences.
" Imperial Geological Institute.
WASHINGTON.—Department of Agriculture, U. S. A.
" Smithsonian Institute.
" U. S. Geological Exploration of the 40th Parallel.
" U. S. Geological and Geographical Survey.
WELLINGTON.—Geological Survey of New Zealand.
" New Zealand Institute.
YOKOHAMA.—German Naturalists' Society.
YORK.—Yorkshire Philosophical Society.

Governments of Madras, Bengal, and the Punjab; Chief Commissioners of Central Provinces and Mysore; Superintendents of Great Trigonometrical and Marine Surveys; Foreign, Home, and Revenue, Agriculture and Commerce Departments.

GEOLOGY OF KASHMÍR (*3rd notice*), *by* R. LYDEKKER, B.A., *Geological Survey of India.*

With a Map.

INTRODUCTION.

Partly owing to the famine-stricken condition of the country, and partly owing to personal disabilities, my geological work during the past summer in the Kashmír Himalaya has been of but very limited extent, and only a comparatively small area of country has in consequence been surveyed. The work which I have accomplished is noticed in the present paper which treats chiefly of the geology of the Tilail and Drás districts, and also of a few places in the valley of Kashmír which had not been previously surveyed. This paper must be read in conjunction with my two previous papers on Himalayan geology, entitled "Geology of the Pír Panjál," and "Geology of Kashmír, Kishtwár, and Pangi."[1] I shall frequently refer to the latter as "my last paper."

[1] Rec. Geol. Surv. India, Vol. IX, p. 155, XI, p. 30.

I.—VALLEY OF THE JHELAM AND KASHMÍR.

I have first to correct the map published in the "Geology of the Pír Panjál" in a very important point. In that map the beds at the Mozaffarábád bend of the Jhelam, north of the Mari (Murree) group, are classified as belonging to the Subáthu group. These beds consist of limestones mingled with a few slaty shales, and very strongly resemble the rocks of the latter group. At my first visit I found a few nummulites near the junction of the red clays and limestones, and I thought that they must have been derived from the latter. Last spring, however, I again crossed the river at Mozaffarábád, and after making a very careful examination of the limestone group, I came to the conclusion that this did not contain nummulites, but that those which I found on my previous visit must have been derived from the red clay series.

The limestones and slates of Mozaffarábád agree very closely in general mineralogical characters with the Uri limestones described in my paper on the Pír Panjál, and I have therefore come to the conclusion that the two must be referred to the same horizon. It is not possible, however, to trace the two continuously together, as to the south-east of Mozaffarábád the slates of the Káj-Nág come into contact with the red rocks of the Mari group.

Slates similar in character to those of the Káj-Nág range, associated with newer rocks, occur in the Hazára district to the south of Mozaffarábád, which are now in course of examination by Mr. Wynne. It seems therefore probable that the limestones of Uri and the slates of the Káj-Nág sweep round the angle of the Mari rocks at Mozaffarábád, and are continuous with similar rocks forming the ranges of the Hazára district, which have a north-easterly in place of the normal north-westerly Himalayan strike.

In the above referred to map other Subáthu rocks are represented to the west of Dewal; these are on the strike of the Mozaffarábád limestones, and it is not improbable that they also belong to the same horizon. It must, however, be borne in mind, that further south to the west of Pindi on the same strike, distinctly nummulitic limestones occur, and as there is great confusion of the rocks in many parts of this line, the position of those to the west of Dewal must for the present remain unsettled.

In my last map[1] the rocks on the left bank of the lower part of the Sind valley were left uncolored; an examination of these rocks shows that they consist entirely of the slates and sandstones of the Panjál series, having a north-easterly dip at the Dal Lake. The rocks up the Trál valley, between Srinagar and the Lidar valley, were similarly left uncolored in the same map. These rocks I now find consist entirely of slates and sandstones, mingled here and there with the Pír Panjál amygdaloids; they must doubtless all be referred to the Panjál series. These same rocks I have traced northwards to the section which I took last year between the Lidar and Sind valleys, and it is therefore apparent that the whole of the rocks

[1] Geology of Kashmír, Kishtwár, and Pángi.

north of the ellipse of carboniferous limestone which occurs near Srinagar must be referred to the Panjál series.

On the opposite side of the valley of Kashmír, at Gúlmarg, I have carried a section up to the central core of gneiss, which here occupies the highest point of the range, and is continuous with the gneiss shown in my last map to the south-east of the Jhelam valley. The gneiss above Gúlmarg has the same relation to the slates and sandstones as has the corresponding gneiss of the Pír Panjál pass to the same series. This relation and the inferences drawn from it will be found in my last paper.

II.—Sind and Tilail Valleys.

The greater part of the Sind valley section has already been described in my last paper. During the past summer, however, I had occasion to re-traverse this line, and some further remarks on the section which occurred to me during this second visit have been added in the present paper. My great object in this journey was to trace the limestone series of Sonamarg and Amrnáth (Ambarnáth) to the north-west, and I shall describe below the sections as they were met with on my route: it may be well in the first place to mention the route I took.

Starting from the valley of Kashmír, I travelled by the Ladák road as far as the town of Drás; from thence I turned off to the westward, crossing the pass into the Tilail valley; I then followed the Kishenganga[1] river as far as Gurais, making several detours to the northward. From Gurais I returned to the village of Bodagrám in Tilail, and from thence struck across the hills in a south-easterly direction *viâ* the Lahani and Gadasir valleys to Sonamarg in the Sind valley. A separate trip from Kashmír to Gurais along the Astor road enabled me to connect the north-westerly extremity of the Tilail section with the previously known rocks of the valley of Kashmír.

At page 47 of my last paper I referred to a mass of gneiss mingled with a few bands of limestone which occurs in the lower part of the Sind valley, south of the village of Wangat. I then suggested the possibility of this gneiss being newer than the slate series. A further examination of these rocks has, however, led me to come to the conclusion that the gneiss series really underlies the slate and amygdaloidal series, and that the former must consequently correspond in position with the gneiss of the Pír Panjál. The peculiarity of the Sind valley gneiss is, that it contains some beds of unaltered blue limestone and others of white crystallised limestone; the occurrence of this limestone with the gneiss cannot, however, of itself, I think, be regarded as of any importance as regards the age of the rock. Very similar limestones occur in the gneiss of the Bhútna river in Pangi, which were noticed in my last paper.

Above this mass of gneiss I have no additional remarks to make on the Sind valley section, until we come to the great limestone series of Sonamarg. In rela-

[1] The name of the Kishenganga river does not appear on the map. It should be applied to the river which rises in Tilail above Gújrond (Goojrond), and from thence flows to Gurais.

tion to this series I must observe that in my last published map, the boundary lines of this formation on the Drás side of the Zoji pass were taken from unpublished notes left by the late Dr. Stoliczka; a traverse of this route by myself has shown me that some error had crept into the map as to the position of the north-eastern boundary of the Zoji-la slates which was put much too near the pass; this error was most probably due to some misinterpretation of the notes left by Dr. Stoliczka.

As I had not proceeded beyond Sonamarg when I wrote my last paper, I shall take up the section from that place; the preceding descriptions of this section will be found at page 46 of my last paper of which this must be taken as the sequel.

An anticlinal axis traverses the Sonamarg limestone series in a north-westerly and south-easterly direction near the village of Thájwaz; this axis, as is noticed by Dr. Stoliczka,[1] is continued from thence along the course of the Sind river as far as the halting place of Báltal, at which point it bends round abruptly to the southward. As we ascend the Sind valley from Sonamarg, we find higher and higher beds forming the exposed base of the anticlinal, till at Báltal the rocks consist in great part of white dolomitic limestones like those of Amrnáth cave, described in my last paper. A great portion of the lower white dolomitic rocks of the latter place are replaced in the Sind valley by blue banded limestones intermingled with slates.

Immediately above Báltal, the limestones, with a north-easterly dip, are succeeded by the slates of the Zoji-la, with the same dip: these slates soon become nearly vertical; they are often columnar or bacillar in structure, and contain bands of limestone; immediately north of the Zoji pass, we find a band of this intercalated limestone some fifty feet in thickness; this limestone is underlaid by slates, and again appears further down across an anticlinal flexure in the same slates. Alternations of slates, micaceous sandstones, and quartzites, with occasional bands of limestone, continue along the Drás road, till we get within half a mile of Mataian: these rocks in many places are greatly disturbed by contortion.

Above Mataian we come upon blue limestones underlying the slates; the former are again underlaid by white dolomitic limestones like those of Amrnáth; these limestones indeed bend round to the east of the Gúmbar (Goomber) stream to meet those of the latter place.

We have already seen that the triassic limestones and dolomites of Sonamarg, according to my view, underlie the slates at Báltal and Mataian, in which respect the sequence here exactly agrees with that which I have shown in my last paper[2] to occur more to the eastward at Panjtarni. Further, we have seen that a distinct anticlinal flexure traverses the limestone series at Báltal, which disproves the

[1] Scientific results of Yarkand Mission—Geology, p. 12.

[2] Page 46.

alleged superposition of the triassic limestones on the Zoji-la slates.[1] Across the Zoji-la pass, however, owing to the great amount of contortion which the rocks have undergone, the sequence cannot be clearly traced, though I incline to think that the whole of the rocks between Báltal and Mataian are newer than the triassic limestone series. Beyond the Zoji pass, however, there occur on the road a few blocks of a gneissoid rock coming from the eastward, which may show that certain older rocks are thrown up by faults within the presumed triassic area. I have no positive proof, however, that such is the case, and I do not therefore desire to lay any great stress one way or the other upon the presence of a few gneissoid rocks within this area.

At Mataian there is a small fold in the white dolomitic limestones, and below this the same rocks continue with a southerly or south-westerly dip to the great bend in the Gúmbar river. At this bend the triassic series is faulted against another great rock series, which has a northerly dip; for a short distance below this bend the river runs along a faulted anticlinal axis, while further down the dolomitic series is continued to the eastward a little to the south of the river: the dolomitic rocks have in this direction been traced a little to the eastward of Drás. The rocks[2] to the north of this fault have a general blackish color when seen from a short distance, which contrasts most strongly with the white colored dolomites to the south. These slaty rocks to the north and east of Drás are abruptly cut off by a great mass of crystalline rocks. These crystalline rocks are mentioned by Dr. Stoliczka in his "Geological Observations in Western Tibet" under the name of syenite, and are traced down the Suru river. In the latter area, according to Dr. Stoliczka, this rock contains large crystals of hornblende and diallage, with occasional nests of epidote and serpentine, together with grey quartz, and albite, and occasionally orthoclase. A rock of this composition is of course rightly named syenite: at Drás, however, the composition of the rock appears to have changed; in hand specimens, which I collected, its constituents are quartz, brown uniaxial mica, and one or two kinds of felspar, and apparently no hornblende. The Drás rock, therefore, seems to be a true granite, and the same composition prevails in these rocks as we proceed to the east.

A portion of the slaty rocks of Drás was considered by Dr. Stoliczka (sup. cit., p. 349) to be of silurian age, while another portion was considered to be of

[1] There appears to be some confusion in Dr. Stoliczka's account of this section. At page 349 of his "Geological Observations in Western Tibet," he observes, "these rocks (Zoji-la slates) are *overlaid*—neglecting interruptions—by limestones and carbonaceous slates," making no mention of the anticlinal in the limestones. At page 12 of the Geology of the Yarkand Mission, he observes that the limestones near Sonamarg have 'a northerly dip on the right bank of the valley,' and immediately afterwards he says, that some four miles to the east on the same strike these limestones which dip towards the slates are *underlaid* by the slates, which is, so far, contradictory. In my last paper on Kashmír geology (p. 45), I assumed from Dr. Stoliczka's first account that there must be inversion. Now that I have visited the spot, however, it appears to be a regular sequence, though somewhat contorted, but a sequence which agrees exactly with the less disturbed one at Panjtarni.

[2] Mem. Geol. Surv. India, Vol. V, p. 347.

carboniferous age; no fossils were, however, discovered. We shall subsequently see that these Drás slates are the equivalents of the Pír Panjál rocks of Kashmír, and therefore appear to be the equivalents mainly of the silurians, though there is no reason why some of their higher beds should not be carboniferous. The same rocks may be traced in a south-easterly direction to Kurtse, where they overlie the gneiss of Suru.

Near the town of Drás itself the slate series has generally a very massive character, showing at a short distance but very indistinct signs of stratification; the rocks consist mainly of brown or purple sandstones, and black, brown, green, and brick-red slates and shales. To the westward of Drás, the same rock-series is continued up the Muski stream, with a generally northerly dip; a little to the south of the same stream, we may trace the bold line of cliffs of the triassic dolomites, which have a generally westerly trend, and the same southerly dip which we observed at Drás. Westward of *Drás* many of the rocks in the *slate* series consist of light colored ribband-jasper, and there are also numerous beds of conglomerate intercalated with the slates. The pebbles in this conglomerate are sometimes water-worn and sometimes angular, and do not generally exceed four inches in their longest diameter; they consist of quartzites, grits, and slates, some of the two latter of which are very similar in character to the main rock. The occurrence of pebbles in these rocks similar to the matrix, may perhaps be explained in the manner in which Sir Charles Lyell explains a similar feature in the Stonesfield slate of England;[1] he there suggests that the pebbles in the conglomerate, which resemble the main rock, may be portions of the same deposit which have been broken up in shallows and re-deposited. The rocks may, however, have been altered before the formation of this conglomerate.

About twelve miles above Drás on the Muski river, a few thin bands of limestone occur in the slate series; nearer the pass, at the head of the river, black slates and conglomerates are the prevalent rocks.

As we approach the pass separating the Drás and Kishenganga valleys, blue limestones begin gradually to appear at the top of the slate series (which has a southerly dip), till finally at the pass itself these blue limestones form the greater portion of the higher part of the series; still further to the south these blue limestones are overlaid conformably by the buff dolomitic limestones continuous with those south of Drás, in which Dr. Stoliczka found triassic fossils.

We therefore find that at the head of the Muski stream a very different condition obtains to what we found at Drás; at the latter place we found a fault separating the Drás slates from the triassic dolomites, while in the former place the two series are connected by an intervening series of blue limestones, the whole being apparently conformable. The inference from this is *firstly*, that the fault which occurred at Drás has here died out, *secondly*, that the intermediate blue limestones belong approximately to the carboniferous series, and *thirdly*, that the Drás slates belong approximately to the silurian series. The carboni-

[1] Student's Elements of Geology, p. 323.

ferous limestone I estimate here at 3,000 feet in thickness, and the triassic as from 4,000 to 6,000 feet.

Down the Tilail valley, nearly to the Búrzil (Boorzil) river, the blue carboniferous limestone continues a little to the south of the Kishenganga, overlying the slates, and itself overlaid by the dolomitic limestones of the trias; these latter, more especially in the pass between Drás and Tilail, from their uniform and homogeneous character, weather into grand tower-like cliffs and crags, showing very little signs of stratification. The banded carboniferous limestones, on the other hand, which generally contain intercalated beds of slate, weather into bands parallel to the stratification.

On the right bank of the Kishenganga river in Tilail, there is an anticlinal axis a little north of the limestone series, and again, beyond this, a synclinal axis; in this synclinal axis there occurs a broken line of presumably carboniferous limestone. To the north of this synclinal I have traced the slate series, which has a generally southerly dip, to the summit of the Tilail watershed; black slates here form the higher portions of the series, while sandstones and grits are more common lower down. Lower down the Kishenganga valley, during a shooting tour made in 1874, I also traced the same slate series to the watershed of the Kelah Shai and Satani streams; it is therefore apparent that this silurian slate series extends to the northern watershed of the Muski and Kishenganga valleys, from Drás to the Búrzil river. I may mention that in the fine-grained black slates which occur high up in the Kelah Shai valley, I found in 1874 obscure organic impressions which I thought might possibly belong to *Graptolites*. I have unfortunately since lost these specimens, so that I cannot confirm this opinion.

Returning to the middle of the Tilail valley, near the village of Bodagrám, we find that green amygdaloids like those of the Pír Panjál are of common occurrence in the slate series, from which I think we may safely conclude that the Drás and Panjál series are of the same age. This coincides with the inference drawn as to the age of the Drás slates from their relations to the triassic dolomites.

We have now to take an oblique cross-section through the great limestone series, from the village of Bodagrám in Tilail to Sonamarg in the Sind valley. In crossing the ridge on the left bank of the Kishenganga, separating that river from the Lahani stream, we first pass over a continuously ascending series of light blue carboniferous limestones with a southerly dip; as we descend on the opposite side of the ridge into the Lahani valley, we find these blue limestones succeeded conformably by bands of white dolomitic limestones, pure blue limestones, green slates, and a peculiar white slaty limestone. On the Lahani stream there occurs a thick band of brownish slates; these and other slates intermingled with a few bands of limestone, with the same southerly dip, extend halfway up the ridge separating the Lahani from the Gadasir stream; here we find the slates overlaid by white, buff, and blue dolomites and limestones. Crossing the ridge into the Gadasir valley, we come upon a synclinal axis, and as we descend we cross the same beds in a reversed direction. The lowest of these northerly dipping beds, however, exposed in the Gadasir stream are the dolomites and limestones, and not the underlying slates seen in the Lahani stream.

It will, I think, be evident from this section that the last-mentioned dolomites and limestones must be the representatives of the pure white triassic dolomites which occur further to the east; it is, however, not quite clear whether the brown slates in the Lahani valley belong to the carboniferous or to the triassic series; as, however, dolomitic limestones and a whitish calcareous slate occur below these brown slates, and as the thickness of the carboniferous limestones, north of the Lahani stream, is about equal to that which occurs more to the eastward, I have thought it probable that the slates near the Lahani stream and the overlying dolomites and limestones all belong to the triassic series, and I have accordingly so colored them in the map. The slates which occur in the middle of the limestones not improbably indicate that we have here a littoral deposit in a subsiding area, and that as subsidence went on more rapidly, limestones were again thrown down over the slates.

As the triassic series has not in this place the homogeneous structure which is so characteristic of it, further to the eastward, the general appearance of the rocks is very different; they do not weather out into the craggy peaks like those of Amrnáth and Drás, but into parallel hollows and ridges, accordingly as the harder or softer beds are more prevalent: in this respect resembling the triassic series at Sonamarg, as described in my last paper.

Reverting now to our section, we find on the left bank of the Gadasir stream, tall cliffs composed of the amygdaloidal rocks of the Pír Panjál series, which I have traced to the south-east into similar rocks forming Shalian ridge, which were described in my last paper; to the north-west these rocks continue on towards Gurais, where I shall have again to refer to them. The boundary between the triassic and silurian rocks continues up the Gadasir stream, and by the two small lakes called Kishan-Sar at the head of the Raman stream, and thence again down the Nichinai stream, till it reaches Thájwaz, where it was described in my last paper. White dolomitic limestones are most prevalent at Kishan-Sar, but towards Thájwaz blue limestones with slates are more prevalent; corals and crinoids are extremely abundant in the dolomitic limestones near the head of the Gadasir stream, the rocks at this place having evidently once formed part of an old coral reef.

For some way down the Gadasir stream, the junction between the slate and limestone series is a faulted one; this is rendered evident by the fact that the higher dolomitic limestones in the Gadasir valley rest against the nearly vertical silurians, while at Thájwaz the limestones in which Dr. Stoliczka found a triassic Ammonite dip towards the older silurians. Lower down the Gadasir stream, however, as we shall see at Gurais, the fault dies out, and there is an apparently uninterrupted succession from the presumably silurian slates to the triassic dolomites.

As accessory evidence in regard to the Gadasir-Nichinai fault, it may be observed that along the whole of this junction, a line of springs of extremely pure water bursts forth. These springs, which have a temperature of about 50° F., in great part supply the two small lakes called Kishan-Sar above referred to. These lakes are situated at an elevation of a little short of 13,000 feet above the sea; and my guide from Tilail told me that they never freeze, even in winter, which is owing to their being supplied by these springs whose temperature I presume to be nearly constant. I at the same time paid a visit to another small lake called Gurasar-Nág, within the silurian area, and consequently off the line of springs; in this lake, which is situated at about the same elevation as the others, I found, at the latter part of August, huge masses of snow floating about in the water, and the temperature of the water at freezing point, while the temperature of the water of Kishan-Sar I estimated at over 40° F., though glaciers drain into it.

From these facts there can be little doubt but that the above referred to line of springs is of very deep-seated origin, which is strongly in favor of their being forced up from the depths of a fault between the limestone and slate series.

I may mention in passing that the mountain lakes referred to above are situated in hollows, the mouths of which are dammed by the moraines of old glaciers, of the former existence of which there are here abundant evidences.

Returning once more to our section, it firstly remains to mention that the band of carboniferous cherty limestone, described in my former paper as occurring at the top of the slate series at Gaggangan (Gungungan) in the Sind valley, and thence continued to the north-west, dies out across the watershed of the Sind valley, and the amygdaloidal silurians of the Shalian ridge consequently come into immediate contact with the slates of the Sind valley, though I am unable to say whether or no the fault is continued.

It now remains to consider the limestone series near Gurais, but before doing so it will be simpler to carry a section from the valley of Kashmír to the latter place, in order that we may the more thoroughly understand the sequence. Starting from Kralpúr (Kralpoora) on the Gurais and Astor road, we find near that village, that the rocks consist chiefly of amygdaloids and slates, an anticlinal axis running through them close to the village. Between Kralpúr and the halting place of Trágbal, the rocks have a general flat northerly dip; the amygdaloidal rocks become relatively fewer as we ascend, and are replaced by green and black or brown slates and sandstones; above Trágbal the rocks consist almost entirely of black slates which preserve the same north-easterly dip till we approach a synclinal axis, near the pass, which is again shortly followed by an anticlinal axis. Descending from the pass towards Kanzalwan, after a few miles we come upon a band of micaceous and gneissoid rocks, with a northerly dip, apparently overlying the black slates. It is, however, quite possible that a fault may occur at the base of these gneissoid rocks, and they may consequently be at the base of the slates. There is, I think, from its mineral character, little doubt but that this gneiss is the same as that of the Pír Panjál, which I have considered in my former papers to be at the base of the slates. Irrespective of any other considerations, it would be extremely improbable that a band of gneiss, in localities so far apart as this and the Pír Panjál, always occurred in the middle of the slates, whereas it would be extremely probable that it should occur always at their base.

Beyond this gneiss, still descending the stream, we find black slates conformably overlying the crystalline band, while towards Kanzalwan a few of the Pír Panjál amygdaloids occur intermingled with the slates, showing that we are still in the silurian series. Leaving Kanzalwan, the rocks along the Kishenganga river consist of the peculiar bluish-green slaty sandstones which were noticed in my last paper as occurring below the carboniferous limestones at Chandanwari, in the Lidar valley. As we approach Gurais, these rocks are overlaid by blue limestones with the same north-easterly dip; the blue limestones are followed by blue and white limestones in bands, the whole being capped by white dolomites like those of Amrnáth. In 1874, during the shooting-trip previously mentioned, I found at the base of these limestones a larger species of *Clymenia*,—a genus characteristic of the upper devonian.

From the conformable position of this limestone series on the top of the slates, and from the occurrence of the above-mentioned fossil, it seems probable that we have here a regular ascending rock series, from the silurian to the trias inclusive; I cannot, however, put in any distinct devonian group, or draw any arbitrary boundary between the carboniferous and the trias. I have accordingly merely coloured in the former rocks as forming a band corresponding to their average width in other localities, which I have made to die out towards the south-east, where, as we have seen, there is a faulted junction between the slate and the limestone series, and where the carboniferous or lower limestones are probably wanting.

Near Gurais bands of a conglomerate occur in the slate series similar to the conglomerate of the Pír Panjál range; this conglomerate contains pebbles of granite or syenite, similar to that of Drás, which rock must, consequently, be older than the slates, and must have existed in its present condition at the time of the deposition of the latter. Pebbles of the same crystalline rocks occur in the bed of the Búrzil river, which seems to indicate that these rocks are continued to the north of the Tilail watershed into the higher valley of the Búrzil. It also seems probable, that these same granitoid rocks have a great extension to the east, forming the rocks on the right bank of the upper Indus at Lè, where they are variously referred to by Dr. Stoliczka as "granitic and syenitic rocks" [1] and "syenitic gneiss" [2]. In the latter districts, they were considered by Dr. Stoliczka as forming, in all probability, part of the silurian series; there being apparently in the Lè district no break between these rocks and overlying shales supposed to be of carboniferous age.

There is, however, quite a possibility of there being a hidden unconformity in the Lè district, which would correspond to the unconformity at Drás, shown by the crystalline pebbles in the slates, and I would suggest that it may possibly turn

[1] Geological Observations in Western Tibet, p. 348.

[2] "Scientific Results of Yarkand Mission"—Geology, p. 15.

out that some of these Dras and Lè crystallines are the representatives of some of the crystallines in Suru and Lahúl, where there is a probability of rocks of two ages being intermingled.[1]

The unusually wide area over which the Pír Panjál conglomerate (if that of Pangi be the same) extends in the slate series, is a very remarkable circumstance, and must clearly be due to some very wide-spread cause. In the Pangi district I have elsewhere stated that it seemed to me to be extremely probable that ice action has been connected with its production, and considering its wide distribution in Kashmír, I am beginning to think whether we must not have recourse to some similar transporting power there, though I have at present no positive proofs to bring forward. The occurrence of gneiss (or syenite?) pebbles in the conglomerate of the Pír Panjál, which, we have seen, cannot belong to the gneiss of that district, may be considered as tending towards the hypothesis of ice-transport.

It now remains to say a few words regarding the area between the Sind valley and the Trágbal and Gurais road. It will be found from my last paper that with the exception of the gneiss in the Sind valley, all the rocks in the valley of that river below Gaggangan belong to the silurian series, the same rocks, with the exception of a few others of carboniferous limestone, bound this area to the southward along the vale of Kashmír; similar rocks bound this area to the north-west on the Gurais road, with the exception of the band of gneiss noticed above; on the north-east the same rocks underlie the limestone series of Tilail. It is therefore evident that the area in question is occupied by rocks of the Panjál series, which strike right across it, but that the centre of this area is penetrated by a mass of gneiss running in from the north-west, which, however, does not reach into the Sind valley. On a former occasion I have found this gneiss occurring high up in the valley to the east of Kralpúr, and on the northern flanks of Haramúk (Haramook). It seems therefore evident that this band of gneiss dies out somewhere on the north-western side of Haramúk, and that the rest of the area consists of the rocks of the Pír Panjál. The area has accordingly been colored in on the map, though the boundaries of the gneiss must be only regarded as an approximation to the truth.

A general glance at the map of the north-eastern side of Kashmír, will, on the whole, show us that the geological features of the country are very similar to those of the Pír Panjál and valley of Kashmír, as treated of in my last paper. We there found that the centre of the Panjál range seemed to be an anticlinal axis, flanked on the outer side by limestones considered to be of carboniferous age, and followed on the inner side by the synclinal axis of the vale of Kashmír containing undoubtedly carboniferous rocks.

Similarly, on the Gurais road, we find an anticlinal axis showing gneiss, followed by the synclinal of the Gurais valley, containing carboniferous and triassic strata again underlaid by silurians to the north-east.

[1] Rec. Geol. Surv. India, Vol. XI, p 60.

To the south-east of Haramúk, this northern anticlinal is not so well marked, as no gneiss is shown in the section; while still further to the south-east, as at Palgám in the Lidar valley, the anticlinal has quite died out, and is replaced by a local synclinal, in which there rests an outlier of carboniferous strata.

The synclinal in the silurians at Gurais, containing carboniferous and triassic strata, is a well marked feature, extending from the former place to Panjtarni and Drás towards the south-east. In many places, however, it will be observed that the original relations of this synclinal have been disturbed by faulting, but not to such an extent as to obscure the general features of the system. To the north of this great synclinal ellipse, we have another slight synclinal containing carboniferous strata in the midst of silurian rocks.

It will have been observed in the course of the preceding sections, that the slates of the Zoji-la, lying in a synclinal ellipse of the triassic limestones, are not represented in the section taken from Tilail to Sonamarg; the synclinal being contracted at this point It is therefore apparent that these slates must die out gradually between the Zoji-la and that point; this has accordingly been so represented in the map, though the north-western termination of these Zoji-la slates is only approximately represented.

In concluding this sketch, I wish to add a few words regarding the probable age of the strata overlying the silurian series, in the Tilail and Drás districts, and their relations to the great limestone series of the valley of Kashmír. I would premise that fossils are of extremely rare occurrence in this series, and that therefore no precise distinctions as to the age of the different beds can be drawn, but only the general homotaxis of the series can be roughly indicated. I have already observed in my last paper, that in the fossiliferous strata of the more eastern Himalaya, the late Dr. Stoliczka found that no distinct devonian or permian periods could be determined from the fossil evidence, but that strata containing a fauna with a distinct silurian *facies* were immediately followed by other strata containing a fauna with a carboniferous *facies*, and the latter again by a triassic fauna. The absence of a distinct devonian and permian period cannot here be explained, on the supposition that during these periods the area was dry land, since (unless there be concealed breaks of which we have no knowledge) there seems to be an uninterrupted succession of strata; and we are therefore driven to conclude that the strata classed by Dr. Stoliczka as silurian, carboniferous, and triassic, must be the representatives of the whole of the European series from the silurian to the triassic inclusive; and that the same probably holds good in the Kashmír area.

On these grounds it would not appear surprising, if we were to find a commingling of the fossils of all these different periods, to a certain limited extent; and such appears to be certainly sometimes the case in India, since Dr. Waagen[1] has described the occurrence of Ammonites associated with Goniatites in the carboniferous strata of the Salt Range, clearly showing a blending of the carboniferous and triassic faunas.

[1] Mem. Geol. Surv. India, Vol. IX, pt. II.

Returning now to our Kashmír limestones, we find that in the valley of Kashmír at Eishmakám and near the Marbal pass, as well as in a few other places, distinctly carboniferous fossils have been found, generally low down in the series; a few similar fossils have also been found at the base of the limestone series of the north of Kashmír, near Shísha-Nág, which seems to correlate the bases of the two local series. Further to the westward at Thájwaz, a triassic Ammonite was found by Dr. Stoliczka somewhat low down in the limestone series, but how low down I am unable to say, because the junction between the limestone and slate series is here a faulted one. A little higher up in the same series I have myself found corals and crinoids.

At the top of the Gadasir stream, I found what seems certainly to be a *Chætetes* in considerable quantity; and at Sonamarg I found one large mass of a *Cyathophyllum* or some closely allied genus. Now, the genus *Chætetes* has been hitherto known in the Himalaya from the Muth series[1] only, which is supposed to be the representative of the European silurian, while we now have it on a line of beds which have yielded a triassic Ammonite. In Europe the genus attained its maximum in the carboniferous rocks, but also ranged both above and below that formation.

Cyathophyllum also, according to Dr Stoliczka, has hitherto been found only in the Muth series in the Himalaya; in Europe this genus ranges from the silurian to the trias.

As far as these two genera go, therefore, it seems that no evidence of the age of the rocks in which they occur can be obtained The discovery of these in the triassic series of India shows that they had a wide range in time here as in Europe.

Again, near Drás, in the dolomitic series, which corresponds to some parts of the limestone series at Thájwaz, very characteristic upper triassic fossils were found by Dr. Stoliczka.[2]

Turning now to the same great limestone series at Gurais, we find that here we have an apparently continuous series from the Panjál slates through the limestones; and that quite at the base of these limestones a species of the genus *Clymenia* was found which is characteristic of the upper devonian of Europe.

Taking, therefore, the whole of this evidence, it is quite clear that the base of the limestone series of Kashmír is of carboniferous, and from the evidence of the *Clymenia* perhaps partly of upper devonian age. The higher dolomitic beds, on the other hand, are clearly of upper triassic age. The only question is where to draw the boundary between the two periods.

Now, at Thájwaz, where the Ammonite was found, and where the junction is faulted, the strata have been colored in the map as of triassic age; it must, however, be said that an anticlinal occurs here, and that no very distinct lithological comparisons are here possible. Moreover, as the whole series is here in sequence,

[1] Stol.: Mem. Geol. Surv. India, Vol. V, part iii, p. 143.

[2] Mem. Geol. Surv. India, Vol. V, p. 349.

and as we have already seen that Ammonites have been found elsewhere in India in strata containing carboniferous fossils, it is not improbable, nay rather it is very probable, that there may here be a mingling of fossils of different periods; and that consequently no hard-and-fast boundaries can be drawn corresponding to the limits of European formations; though at the same time it should be observed that it may hereafter be quite possible to distinguish independent Indian life-zones in these strata, should abundant fossils ever be discovered in them.

In the map wherever there is a regular sequence of strata from the Panjál slates to the upper triassic dolomites of Drás and Amrnáth, the limestones underlying the latter have been classed as carboniferous. Along the faulted line of Thájwaz the whole series has been referred to the trias from the evidence of the Ammonite, which, as above said, may be doubtful; and there may therefore be a few carboniferous beds at the base of the anticlinal, while at the same time some of the higher slates may be of carboniferous age.

We may also observe that since the limestones of the valley of Kashmír itself, which contain numerous carboniferous fossils at their base, are in many places thicker than the carboniferous band in the limestone series of the north of Kashmír, it is more than probable that some portions of the former are the representatives of the triassic series. At Mánasbal[1] this has already been proved to be the case, from the identity in mineral character of the white dolomites at the top of the series in that place with the similar rocks of Drás and Amrnáth. In the south-eastern extremity of the valley of Kashmír, the whole of the limestone series has the same mineralogical composition throughout, and the higher beds have hitherto yielded no fossils. We have therefore no direct evidence to connect the upper beds there with the trias of Drás, and they must therefore remain on the map as of carboniferous age, until evidence can be produced to the contrary.

Finally, we must come to the conclusion that the Kashmír limestone series forms an unbroken sequence of strata, which must be the equivalents of all the European strata from the upper devonian to the upper triassic inclusive; but as, with one exception, no devonian or permian fossils have been discovered, the strata have been colored on the map as carboniferous and triassic only.

From the distribution of the limestone series in Kashmír, it seems pretty evident that these strata were once connected and extended over the whole area, and have been brought into their present form by disturbance and denudation.

The strata overlying the triassic dolomites of the Zoji-la being sandy and clayey in composition, were probably deposited in a shallower sea than that in which the older limestones were laid down; and since no newer strata are known in this area, it is possible that the bottom of the sea was being upheaved at the time of the deposition of these slates, and that the area has not subsequently been submerged.

[1] Rec. Geol. Surv. India, Vol. XI, p. 47.

The local occurrence of clayey and sandy rocks in the limestone series on the horizon of pure limestones may also suggest that the sea in which these limestones were laid down was in places shallow, and near to land; the presence of coral reefs also attests either the presence of land, of a shallow sea, or of a sea filled with atolls. Where the ancient land surfaces were, we have at present no mean of indicating.

III.—Traces of old glaciers in Kashmír.

As there has been considerable discussion carried on in the "Records" of late concerning the supposed glaciation of parts of the Upper Punjab, I have thought it would not be out of place to state here any facts which I have observed as to evidences of former glaciation in Kashmír and the neighbouring mountains.

I will first observe that I have nowhere observed any traces of glaciation in the valley of Kashmír itself. I have already observed in my last paper,[1] that I cannot agree with Professor Leith Adams[2] in considering the Báramúla gravels as affording any evidence of former glaciation; and I know of no other deposits in the valley which could possibly be considered to be due to the same agency. Neither have I seen any traces of erratics, perched blocks, *roches moutonnées*, or scratched rock-surfaces within the limits of the valley. I may add that I think it almost certain that the Báramúla gravels are much older than the old glacial moraines of other parts of Kashmír, which are always entirely undisturbed by tilting.

The lowest elevation in Kashmír at which I have observed glacial phenomena is in the Sind valley near the village of Kúlan, (marked in the map issued with my last paper), at an elevation of about 7,000 feet; here I have seen very distinct glacial striation. Mr. Drew,[3] moreover, mentions the occurrence of a well grooved *roche moutonnée* near the same place at an elevation of about 6,500 feet above the sea level, or 1,500 feet above the level of Srinagar. This is the lowest spot in Kashmír, where there seems to be undoubted evidence of former glacier action.

Above this elevation traces of old glaciers are extremely numerous in the Kashmír Himalaya; and I will here only notice one or two well marked instances.

At Gúlmarg, on the Pír Panjál, many of the hillocks of detrital matter stretching out into the valley seem undoubtedly from their shape to have formed part of an old glacier moraine, though I have not succeeded in obtaining any grooved rocks; the elevation of this place is somewhat short of 8,000 feet.

At Sonamarg and Thájwaz, in the upper Sind valley, there is an undulating plateau, at an elevation of about 9,000 feet, which is composed entirely of detrital matter, to a depth in places of at least 300 feet. This plateau has been admirably described at page 220 of Mr. Drew's above-quoted work on Kashmír, and is there clearly shown to have once formed an old glacier moraine. I have found glacial

[1] p. 33.
[2] Wanderings of a Naturalist in India, p. 171.
[3] Jummoo and Kashmír Territories, p. 220.

scratches on some of the angular blocks of this moraine. The blocks in this moraine consist almost entirely of the amygdaloidal rocks of the Shalian ridge, while the moraine itself rests in a hollow of the Sonamarg limestone. At an elevation of about 2,000 feet above the Sonamarg plateau three small glaciers still nestle in sheltered ravines on the northern aspect of the Shalian ridge. Mr. Drew thinks it probable that the whole of the Sind valley nearly as far down as Kangan was formerly occupied by a glacier—a conclusion with which I agree The hill of limestone separating the village of Sonamarg from the valley of the larger Thájwaz glacier, represented at page 219 of Mr. Drew's book, is at its lowest point some 500 feet above the level of the Sonamarg moraine, and has a peculiarly rounded appearance, which suggests the probability of this hill having been once buried beneath the ice of the old glacier.

On the Ladák side of the Zoji pass, we find at Drás, which has an elevation of some 10,000 feet, two huge embankments of detrital matter, some four or five miles in length, extending from the crystalline ridges of the north into the Drás valley, and consisting almost entirely of boulders of the crystalline rocks strewing the surface of the slate rocks of Drás. From the form of these masses of detrital matter, I think that they are certainly due to former glacial action; which opinion is strengthened by the great distance over which the boulders have travelled, and by the very slight fall of the ground on which they lie,—a fall so slight that I cannot think these huge blocks could have possibly been moved along it by the action of water alone, especially as there is no great river along the line of their course.

It now remains to consider certain granitoid blocks in the Jhelam valley below Báramúla which Colonel Godwin-Austen[1] suggests may have been brought into their present position by the aid of ice-action. In discussing the question of the glacial or non-glacial origin of the deposits in which these blocks occur, it will be necessary to go somewhat into the history of the Jhelam valley.

On referring to the outline map accompanying my paper on the Geography of the Pír Panjál, it will be seen that there are two masses of gneiss, one on either side of the valley, above and below Rámpúr, but which do not extend down into the stream itself. It is from these masses of gneiss that the boulders in the river bed have been derived; and it only remains to consider the means by which they have attained their present position.

The first of these masses of gneiss occurs a little to the south of the town of Naushara; this gneiss extends into the watershed of the mountain torrents, which descend into the Jhelam valley, so that it is quite possible for blocks of it to be carried by water into the Jhelam. Immediately below Naushara we come upon an alluvial deposit in the river, which is chiefly composed of blocks of this gneiss, which, as being harder, remains after the slate boulders from the neighbouring cliffs have been ground to powder.

At Rámpúr this alluvial formation contains gneissic blocks, some of which are as much as 15 feet in diameter; the whole formation is at least one hundred

[1] Proc. Geol. Soc., London, 1864, p. 383.

feet in thickness on the left bank of the river. The included blocks are all more or less rounded and water-worn, while the matrix in which they are imbedded is here but little stratified. As we descend the river, the blocks of gneiss continue to decrease in size, till we come upon the sharp bend in the river below Rámpúr; here a fresh stream of gneiss blocks has come down a tributary stream from the second gneiss mass in the Káj-Nág range; some of these blocks have a long diameter of upwards of 20 feet.

Still continuing our survey down the river, we find the gneiss blocks again becoming smaller and smaller, and half-way to Uri the alluvial deposit is seen to be most distinctly stratified. All the gneiss boulders have their long axes inclined up the stream and towards the river-bed at an angle of about 30 ; so that one of the flat sides of each boulder is opposed to the flow of the stream, as we find to be the case in any deposit of modern river pebbles.

The summit of the alluvial formation is level, forming high-level plateaux on either side of the river. At Uri we find a similar plateau, some 200 feet in thickness, formed of the red Sirmúr rocks of the neighbouring hills; the pebbles in this deposit are rounded, and have the same relative position in regard to the stream as the gneiss blocks higher up. A few small gneiss blocks are found in the Uri deposit.

Below Uri the same formation runs along either bank of the river with the same "hanging level" often between 200 and 300 feet in thickness; a few gneiss pebbles occur in this deposit; the other boulders consist of the Sirmúr sandstones, some of them of large size.

A few miles above Hatian we again find a great number of rounded boulders of porphyritic gneiss embedded in the alluvial formation, some of which have a long diameter of over 10 feet. It is probable that these blocks have come down across the Jhelam from the peaks of the Káj-Nág immediately to the north, where the same gneiss doubtless occurs, though I do not know its correct position. Small blocks of this gneiss can be traced from Hatian as far as the bend of the river at Mozaffarábád.

It will be gathered from the above observations that the whole of the gneiss blocks in the Jhelam valley have followed the course of tributary mountain streams, have not been carried across intervening ridges, and are imbedded in an aqueous formation. Further, there are not the slightest traces of glacial action on any of the hard slate rocks in the Upper Jhelam valley, which ought to have existed, as they do in other places, had glaciers extended into the Jhelam valley.

Again, the Jhelam itself is able to roll and carry down the gneiss blocks which now lie in its course, and *a fortiori* the mountain streams with a fall ten times as great could easily have rolled them down in flood time from their original position.

A tthe same time, I think it extremely probable that many of these glacial blocks were carried some way down the lofty cliffs of the Panjál and Káj-Nág ranges by ice, at a time when we know that the glaciation of the Himalayas was much greater than at present.

My only point is, that I can see no evidence of glaciers having ever extended down to the level of the Jhelam; and that the gneiss blocks could have perfectly well attained their present position by debacle action.

It will be gathered from the above observations that the Jhelam is now a denuding and not a depositing river, as it was when these alluvial formations were laid down; from which we may probably infer that great changes of level have taken place since the period of those deposits, which may have afforded greater facilities at certain times for the movements of the blocks.

In conclusion, we may state that on the mountains of the north side of Kashmír we have distinct evidence of a former glaciation at an elevation of some 6,500 feet above the sea-level, while on the south side we know of none below 8,000 feet. In the vale of Kashmír itself, and in the lower Jhelam valley, we at present have no distinct evidences of glaciation.

As far, therefore, as this negative evidence goes, it tends to disprove any former glaciation of the outer hills and Upper Punjab, because, if there had been any glaciation of the latter, there would most assuredly have been a far greater glaciation of the valley of Kashmír and the neighbouring hills, since even at equal elevations the present glaciation of the Himalaya increases as we pass towards its central axis.

CORRECTIONS TO MAP.

For "Panjtaria," *read* "Panjtarni."
For "Sonamaro," *read* "Sonamarg."

INDEX.

For "Kareewahs," *read* "Karewahs."
For "Zogi-la," *read* "Zoji-la."

FURTHER NOTICES OF SIWALIK MAMMALIA *by* R. LYDEKKER, B. A., *Geological Survey of India.*

[WITH A PLATE.]

Since my last notice of Siwalik Mammalia,[1] another collection has been received from Mr. Theobald, and a few interesting teeth have been obtained through Mr. Blanford from Sind. Many of Mr. Theobald's specimens have added considerably to our knowledge of the dentition and osteology of previously known species. On the present occasion I shall only very briefly notice the most interesting of the majority of the new specimens, reserving their fuller description for a future occasion, when I shall have an opportunity of giving figures of them. One specimen, however—the jaw of a large monkey—is of so interesting a nature, that I have given a figure of it here, as it would otherwise have been long before I should have been enabled to do so. On the same plate I have likewise had drawn the molars of the *Macacus* and the *Rhizomys* described in my last notice.

Among the rarer specimens is the greater portion of one side of the lower jaw of *Anthracotherium punjabiense*, showing the three true molars.

PRIMATES.

PALÆOPITHECUS SIVALENSIS, n. gen. nobis.

The most interesting specimen in the whole of Mr. Theobald's Siwalik collection is the fragmentary palate of a large anthropoid ape, represented in figures 1 and 5 of the accompanying plate. This specimen is of the highest interest, because, with the exception of a single canine tooth obtained years ago by Dr. Falconer from the Siwaliks, it is the only specimen which affords us any evidence of the former existence of anthropoid apes in India, or indeed, if we except *Dryopithecus* and the smaller genera, in the whole world.

The specimen was obtained by Mr. Theobald from the Siwaliks of the Punjab, somewhere near the village of Jabi, though I do not know the precise locality; it was originally in three fragments, but two of them have been united; and as the fractures are quite recent, I presume that the specimen was broken up by the natives in extracting it from its matrix. The portion that remains shows the greater part of the right maxilla, broken near the centre of the palate, and superiorly at the zygomatic root; the second fragment is a portion of the left maxilla; in the figure the two fragments have been placed in their relative position in the proportions of the palate of the living Orang.

The fragment of the left maxilla contains the complete penultimate, and the bases of the first and last molars. The right maxilla exhibits the entire dental series, from the outer incisor to the last molar; the crown of the incisor, of the penultimate premolar, and the summit of the canine have been broken off; the penultimate molar has the centre of its crown somewhat decayed. The premolars are two in number, which shows that the specimen belongs to the Catarhine

[1] Records, Vol. XI, p. 64.

section of the Primates; all the teeth are well worn, which shows the animal to have been adult at the time of its death

The molars and canine are arranged in a straight line, and there is a small diastema between the canine and the outer incisor; each tooth of the molar series is inserted by four fangs. In the true molars, the last is the smallest of the three; each tooth carries four cusps on the masticating surface, which form an irregular quadrangle, arranged obliquely to the long axis of the tooth; thus, in relation to a line drawn transversely across the palate, in front of any one molar, we find the antero-external cusp placed first, then the antero-internal cusp, then the postero-external, and lastly, the postero-internal; an imperfect ridge connects the two internal cusps. The crowns of the molars are square or oblong, with their angles rounded off. The one remaining premolar carries two cusps on its masticating surface: both this and the penultimate premolar are remarkable for the shortness of their antero-posterior diameter in relation to the transverse. The canine is a short and blunt conical tooth, with the outer side of the crown rounded, and the inner side bevelled away obliquely from base to summit; no portion of the tooth which remains has been at all affected by wear. The fang of the incisor is small and laterally compressed.

The profile view of the specimen (fig. 1) shows the fangs of the molars and the root of the zygoma which arises above the interval between the first and second true molars; in front of the zygoma there is a channelled hollowing of the jaw, in front of which the fang of the canine bends round in an arch.

From the shortness and bluntness of the canine it is inferred that the jaw belonged to a female individual.

With this description, we may proceed to compare the new jaw with the jaws of other Primates. First, we shall have no difficulty in saying that our specimen does not belong to either of the genera *Semnopithecus, Macacus*, or *Cercopithecus* and their allies, because in those genera the cusps on the molars are much higher and sharper, and are arranged in pairs directly transverse to the long axis of the tooth; in addition, the last molar in those genera is always as large, or larger, than the first, and the angles of the molars are square.

In *Cynocephalus* and its allies the teeth have much the same general characters as in the last group, and the last molar is much larger than the first.

As we have already seen, the Siwalik jaw cannot belong to the Platyrhine monkeys, and there only remains, therefore, the group of the *Simiæ*, or the anthropoid apes and man to which it can belong. Now, in all the anthropoid apes and in man the molars are exactly of the pattern of those of our specimen, and there can be no doubt but that the latter belongs to this group. The molars, however, of these apes and of man are so much alike, that it is, I believe, frequently quite impossible to distinguish isolated molars, and we can only therefore arrive at specific or generic distinctions by a comparison of the whole dental series.

Commencing with the lowest of the anthropoid apes—*Hylobates*—we find that the general structure of the molars of that genus is much the same as in the

Siwalik jaw: the premolars are, however, much squarer, the canine relatively longer and sharper, and grooved and concave internally; further, the face in the Siamang is shorter, the hollow in front of the zygoma less deeply channelled, and the canine more approximated to the zygoma, and its alveolus much less arched than in the Siwalik jaw. Finally, as a character of less importance, all the species of *Hylobates* are of much smaller dimensions than the animal to which the fossil jaw belonged.

There now remain only the Orang, Chimpanzee, and Gorilla among the living anthropoid apes, with which to compare our specimen. For this comparison I have drawn up the following tables of the dimensions of the upper teeth in these animals, and in man and *Hylobates*, which it may be well to study before proceeding further.

Table showing dimensions of upper teeth in the higher Primates.

	Siwalik jaw ♀	Simia satyrus ♀	Simia satyrus. ♂	Troglodytes gorilla ♂	Troglodytes niger ♂	Human ♂ European.	Hylobates syndactylus ♂
Antero-posterior diameter of outer incisor .	0·30	0·30	0·33	0·30	0·30	0·25	0·13
Transverse ditto of ditto ditto	0·19	0·23	0·25	0·25	0·26	0·18	0·18
Antero-posterior diameter of canine ..	0·53	0·46	0·68	0·80	0·62	0·34	0·36
Transverse of ditto	0·51	0·38	0·59	0·60	0·45	0·22	0·27
Length of molar series	1·87	1·94	2·13	2·70	1·80	1·55	1·21
Ditto of premolars	0·58	0·70	0·74	0·90	0·61	0·50	0·43
Ditto of true molars	1·31	1·26	0·48	1·80	1·20	1·05	0·80
Ditto of penultimate premolar	0·30	0·35	0·39	0·45	0·31	0·25	0·25
Width of ditto ditto	0·50	0·49	0·50	0·64	0·42	0·39	0·25
Length of last ditto ditto	0·30	0·35	0·39	0·48	0·32	0·25	0·25
Width of ditto ditto	0·35	0·49	0·50	0·60	0·44	0·39	0·24
Length of 1st molar	0·45	0·43	0·50	0·55	0·45	0·36	0·28
Width of ditto	0·51	0·45	0·53	0·60	0·49	0·43	0·30
Length of 2nd molar	0·50	0·42	0·49	0·63	0·43	0·38	0·30
Width of ditto	0·51	0·48	0·53	0·60	0·49	0·43	0·31
Length of 3rd molar	0·41	0·42	0·49	0·60	0·35	0·35	0·28
Width of ditto	0·46	0·48	0·53	0·60	0·46	0·41	0·30

Table showing relative lengths of first upper true molar and last premolar in the higher Primates.

	Length of 1st molar	Length of last premolar.	Difference between these lengths	Proportionate length of P. M. 4 on scale of Siwalik jaw.	Excess of real over proportionate length.
Siwalik jaw	0·45	0·30	0·15	0·30	0·00
Human ♂	0·36	0·25	0·11	0·24	0·01
Troglodytes niger ♂ ..	0·45	0·32	0·13	0·30	0·02
Simia satyrus ♂	0·50	0·39	0·13	0·33	0·06
Ditto ♀	0·43	0·35	0·07	0·28	0·07
Hylobates syndactylus	0·28	0·25	0·03	0·18	0·07
Troglodytes gorilla	0·55	0·48	0·07	0·36	0·12

The first of these two tables exhibits merely the absolute dimensions of the different teeth; while the second is intended to show the relative lengths of the first molar and the last premolar in the same group. In the fourth column of that table is given what would be the length of the last premolar, if that tooth bore the same relationship as regards length to the first true molar, which it does in the Siwalik jaw. From that table it will be seen that the new jaw is distinguished from the jaws of all other Primates by the relative smallness of the antero-posterior diameter of the last premolar; this shortness is in excess of what occurs in man, in which the same premolar is relatively shorter than in all the other higher Primates; next to man in this respect comes the chimpanzee, then the orang, and last of all the gorilla; and it is worthy of notice that the two species which (excepting man) exhibit the greatest variety in this respect are placed in the same genus. Professor Owen, at page 446 of his "Odontography," notices the small antero-posterior diameter of the premolars in the chimpanzee, as distinguishing it from the orang, and approximating it to man. The new Siwalik jaw, as we have seen, stands on the opposite side of man to the chimpanzee in this respect, and therefore should be still more removed from the orang. The new jaw agrees with that of the orang, gorilla, and chimpanzee, in having the molar series approximately straight, and with no indications of the horse-shoe form which occurs in the human subject; it therefore belongs to a true ape.

Turning our attention once again to the first of the two tables of measurements, we may note in what other respects the fossil jaw resembles or differs from the jaws of the orang, the chimpanzee, the gorilla, and man. In regard to the relative length of the last molar, we find that the fossil agrees most closely with the chimpanzee and man, in both of which this tooth is much shorter than either of the other true molars. In the orang there is a very slight difference between the lengths of the first and the third true molars; in the gorilla, on the other hand, the last molar is much larger than the first. This difference in the relative lengths of the first and last molars in the gorilla, and the Siwalik jaw, together with the difference which we have already seen to obtain between the last premolars of the same, renders it evident that there is no great affinity between these two, and makes it unnecessary to carry our comparisons any further in this direction.

Comparing the dimensions of the molars of the fossil jaw with those of the female orang, we find that the true molars of the former are larger than those of the latter, and that the united length of the true molars is also greater. When, however, we take the whole molar series, we find that the five teeth of the female orang have an absolutely greater united length than the same five teeth in the Siwalik jaw, this being of course due to the small size of the premolars in the latter. In the chimpanzee, the length of the united molar series is less than in the Siwalik jaw, but the united length of the two premolars is greater, while the length of the three true molars is less: the proportions in the human jaw are in this respect nearest to the fossil.

Again, in the width (transverse diameter) of the base of the outer incisor, the fossil jaw is closer to man than to any of the large apes. In man there is no diastema between the canine and the incisor; in the orang this diastema is larger than in the chimpanzee, which in this respect approaches man. In the fossil jaw this diastema is very slightly larger than in the orang.

The dimensions of the base of the canine are considerably stouter in the fossil jaw than in either the female orang or the male chimpanzee, and approach those of the male orang and gorilla; though the shortness of the crown proves, as we said, that our specimen belongs to a female. In the female orang there is a disk of wear on the posterior border of the canine, which does not occur in the fossil specimen.

The following summary exhibits the points of resemblance and difference between the fossil jaw and the jaws of man, the chimpanzee, and the orang, which are the only three species which are closely related to it:—

MAN.

Resemblances.—Shortness of premolars; small size of last molar and of incisor.
Differences.—Straight line of teeth; large canine and diastema.

CHIMPANZEE.

Resemblances.—Straight line of teeth; shortness of premolars in a less degree; small size of last molar; large canine and diastema.
Differences.—Small incisor.

ORANG.

Resemblances.—Straight line of teeth; large canine and diastema.

Differences.—Shortness of premolars; small size of last molar; difference in wear of canine, small incisor.

It thus seems to be apparent that the fossil jaw has most points of resemblance with the chimpanzee, and that when it differs from that species it has an ultra-human character. It now remains to consider to what fossil form the jaw presents any points of affinity, and we will first direct our attention to the Siwalik Primates.

As regards size alone, the only one of the jaws of Siwalik Primates represented in Plate XXIV of the first volume of the "Palæontological Memoirs" which could possibly have any affinity to our specimen, is that of *Semnopithecus subhimalayanus* (figs. 1 and 2); the teeth of that jaw, however, and of all the specimens on the same plate, are of the semnopithecine type, and have therefore no affinity to our fossil The same remark of course applies to the teeth of *Macacus* represented in figs. 3 and 4 of the plate accompanying this paper

One other tooth of a quadrumanous animal from the Siwaliks is, however, described and figured by Falconer on page 304 of the first volume of the "Palæontological Memoirs;" this specimen consists of the crown of the upper canine of a large ape allied to the orang; the specimen evidently belonged to a male individual, and is somewhat larger than the canine of the male orang. Our fossil jaw, which, as we have already seen, belonged to a female, has teeth somewhat larger than those of the female orang; there is therefore every probability that Falconer's canine and our new jaw belonged to the same species.

Turning, now, to the fossil quadrumanous animals of Europe, the only three genera with which I am acquainted which are likely to have any affinity to our specimens are *Mesopithecus*, *Pliopithecus*, and *Dryopithecus*.

Mesopithecus, from the Pikermi beds,[1] is of small size, and is regarded as being intermediate between *Hylobates* and *Semnopithecus;* the teeth are, however, distinctly of the semnopithecine type, and consequently quite different from those of our fossil.

Pliopithecus,[2] from the Miocene of France and Switzerland, is also of small size, and resembles *Hylobates* so closely, that it is referred by Professor Rutimeyer to that genus.

Dryopithecus,[3] from the Miocene of France, is an ape of larger size, which is, I believe, only known from the lower jaw and some limb-bones, and which from the small size of the canine and diastema is regarded as having an affinity to

[1] "Animaux fossiles et Geologie de l'Attique," Gaudry, Pl. I.

[2] Lartet: "Comptes Rendus," Vol. 2, p. 222, and plate. Heer: "Primeval World of Switzerland," Vol. II, p. 82, Pl. XI.

[3] Lartet: sup cit. Owen, "Palæontology," p. 383.

man. The antero-posterior extent of the second premolar, according to Professor Owen, is, however, greater than in the chimpanzee, and therefore still greater than in the Siwalik fossil; the latter, however, agrees with *Dryopithecus* in having narrow incisors.

Reviewing the whole of the foregoing facts, it does not appear that our fossil jaw agrees precisely with the jaw of any known living or fossil anthropoid ape, though it seems to make the nearest approach to that of the chimpanzee, and also shows some points of affinity with the jaws of man, *Dryopithecus*, and the orangs. The resemblance between the Siwalik jaw and that of the chimpanzee does not, however, appear to me to be so close as to warrant our classing the two under the same genus, because, with the very marked difference which occurs in the relative dimensions of the last premolars in the two jaws, there is every probability that equally well marked differences existed between the crania of the two animals. It must, however, be again borne in mind that the chimpanzee and the gorilla, which present such difference in the form of this tooth, are classed in the same genus.

Since I do not think that we are justified in referring the Siwalik jaw to any known genus, I propose to form for it the new generic name '*Palæopithecus*,' with the specific affix of '*sivalensis*.'

I can only hope that on some future occasion we may be fortunate enough to come across the cranium of this most interesting relic of the past, when we shall be able with some approach to certainty to assign to it its exact affinities, which with our present meagre specimens we can only vaguely guess at. We can only say that there lived in the Siwalik period of India, a huge anthropoid ape intermediate in size between the orang and the gorilla, the males and females of which were provided with canines exceeding in size the other teeth, and that those of the former bore about the same proportion to those of the latter as we find prevailing in the living anthropoid apes. Further, in the form of its teeth, this ape was nearest to the chimpanzee; but in the points in which it differed from that species, it shows great resemblances to the teeth of man.

I will conclude this notice with a few general considerations regarding the past and present distribution of the anthropoid apes. If this distribution in time and space be tabulated, as is done in the accompanying note,[1] it will, I think, be apparent that such living and fossil anthropoid apes as we are now acquainted with are merely a few from a large number of species which once existed on the earth.

	Miocene.	Pliocene.	Recent.
[1] *Troglodytes*	...		W. Africa.
Simia	...		Borneo and Sumatra.
Palæopithecus	...	N. India.	
Dryopithecus	W. Europe.		
Hylobates	...		Malaya, Assam, and China.
Pliopithecus (=*Hylobates* ?)	W. Europe.		

Further, it seems hardly to admit of doubt that three such closely allied genera as *Troglodytes*, *Palæopithecus*, and *Simia* must have had a common parentage and a common ancestral home. For three tropical or sub-tropical genera inhabiting respectively Western Africa, Northern India, and Sumatra and Borneo, the unknown common home may have possibly been situated in the Indian Ocean, being in fact the hypothetical sunken southern continent, whether it be called 'Lemuria,' 'Indo-Oceania,' or what not, to the former existence of which so many separate lines of evidence point. This vanished land was probably once the common home of the African and Indian ostriches,[1] which must have had a common centre of dispersion. Here also we may possibly look for the old home of the *Manis* of Siwalik and modern India, and of modern Africa.

If this hypothetical sunken southern continent[2] was the centre of dispersion of the anthropoid Primates, it is not improbable, nay rather it is almost certain, that numbers of species and genera must have lived and died, and finally become extinct, on that continent, and that only some of their descendants reached the borders of that continent—in other words, Africa, India, and Borneo. If this be so, it is probable that all records of some anthropoid Primates have long since, and for ever, been entirely removed from human cognizance, while it is possible that among those may have been forms nearer to man than any of those of which we have any records. On this supposition it is possible that we may never discover the "missing links." On the other hand, we have in the tropical countries which border the Indian Seas the probable periphery of this sunken continent, and it is among the unexplored tertiaries of these countries that we may yet hope to find fossil forms of *Primates*, which may tend to bridge the great gulf which now exists between the highest known ape and man. Of these countries, the geology of Africa and Sumatra and Borneo is virtually unknown. In India only a few scattered localities have hitherto yielded mammalian remains, and remains of Primates are of extremely rare occurrence in them. Thus, in the much-worked Siwaliks we only know of two specimens of the remains of anthropoid apes, which have been discovered at an interval of many years apart, among thousands of specimens obtained. There is, therefore, no reason to assume that other forms of anthropoid apes did not exist in that period. In Central and Southern India, with the exception of the little known Perim beds, we have no equivalents of the Siwaliks; and there is here therefore abundant room for older Primates to have existed without our having the least knowledge of them.

In the newer Norbudda group scarcely any small fossils have been collected; and yet there is an absolute certainty that many forms of Primates

[1] STRUTHIO ASIATICUS, M.-Edwards, "Oiseaux Fossiles de la France," Vol. II, p. 587, and article in present number.

[2] Mr. Wallace ("Tropical Nature," p. 329) has come to the conclusion that "Lemuria" never existed, or that it at all events must have disappeared before the miocene. There appears to me, however, to be a great weight of evidence in favor of a former land connection between the continents of the old world, though this connection may very possibly have disappeared in comparatively early Tertiary times.

must have existed at that time, many of which were probably distinct from living species.

Our knowledge, therefore, of the tertiary faunas of the Tropics and Sub-Tropics is really extremely slight; and until this slight knowledge has been amplified by the fullest explanation of every tertiary rock stratum in Africa, India, and Malaya, no one is entitled to assert that man and the anthropoid apes had no common ancestor, because no such ancestor has hitherto been discovered; and even if such exploration were made without results, there remains the hypothetical sunken southern continent, with the disappearance of which may also have disappeared the "missing links."[1]

Finally, one other lesson is to be learnt from the Siwalik ape. We know that the living anthropoid apes dwell only in the deepest gloom and solitude of primeval forests, where vegetation grows luxuriously, and offers a constant supply of fruits throughout the year. From this we may probably infer that the Siwalik ape inhabited a similar forest-clad country, and that, consequently, the present Siwalik area of the Punjab was in parts at all events clothed with forests in which dwelt the *Palæopithecus*, instead of being, as now, a sun-scorched and somewhat desolate region. Evidence of the former existence of these forests is, as I have previously remarked,[2] afforded us by the occurreuce of numbers of fossil tree-stems in various parts of the Siwaliks.

MACACUS SIVALENSIS, *nobis*.

In figs. 2 and 4 of the accompanying plate are represented the two fragmentary upper jaws of *Macacus sivalensis*, which were described by me on page 66 of the last volume of the "Records," and which, therefore, need no further notice on the present occasion.

RODENTIA.

RHIZOMYS SIVALENSIS, *nobis*.

The specimen drawn in fig. 3 of the same plate is a fragment of the left ramus of the mandible of the *Rhizomys* described by me at page 100 of the last volume of the "Records," and which I then considered to belong in all probability to a new species. The first molar has been broken away in the specimen but the second and third molars are in excellent preservation; the greater part of the incisor is seen on the inferior border.

PROBOSCIDIA.

DINOTHERIUM INDICUM, Falc.

A detached first lower true molar of a *Dinotherium* has been obtained through Mr. Blanford from the Laki Hills of Sind, which is larger than and of different shape from the corresponding tooth in the lower jaw of *Dinotherium*

[1] See an article on this subject in the Quarterly Journal of Science for October 1878.

[2] Rec. Geol. Surv. India, Vol. IX, p. 100.

pentapotamiæ from Sind, noticed at page 75 of the last volume of the "Records", and which agrees so exactly, as regards dimensions, with the base of the corresponding tooth in the lower jaw of *D. indicum* from Perim Island represented in fig. 6 of plate 35 of the "Fauna Antiqua Sivalensis," that I have considered it to belong to that species.

The tooth is considerably worn, and carries three equal sized transverse ridges, which show no sign of a median longitudinal division, which, with the bluntness of tho ridges, shows that the tooth did not belong to a *Trilophodont Mastodon.* The tooth is relatively narrow in proportion to its length, which shows that it belongs to the lower jaw, while the greater elevation of the inner side of the ridges shows that it belonged to the left side. On the outer and posterior sides of the tooth there is a large thick cingulum.

I have given below the dimensions of this tooth, together with those of the corresponding tooth of *D. giganteum* in the large Eppelsheim cranium, and of the corresponding tooth in the above-mentioned jaw of *D. pentapotamiæ* :—

	New tooth.	*D giganteum.*	*D. pentapotamiæ.*
Length of tooth	3 9	3·5	2·35
Width of 1st ridge	2 5	2·6	1·8
" of 2nd "	2·5	2 6	1 8
" of 3rd "	2·4	2 2	1·7

The tooth is slightly larger than the corresponding molar of *D. giganteum,* in which it agrees with Falconer's fragment, and is far too large to have belonged to *D. pentapotamiæ;* it is further distinguished from the same tooth in both those species by the presence of the large cingulum.

If now we turn to the description of the above-mentioned jaw of *D. indicum* on page 407 of the first volume of the "Palæontological Memoirs,"[1] we shall find that the dimensions of the base of the crown of the first true molar are as follows—length 4, width 2·8; these dimensions agreeing very closely with those of our new tooth. The latter further agrees with a fragmentary tooth of *D. indicum* from Perim Island, described by Dr. Falconer at page 397 of the first volume of the "Palæontological Memoirs," in the great thickness of the enamel, which in both measures 0·25 inch; in *D. pentapotamiæ* and *D. giganteum* the enamel is much thinner. Although, therefore, the perfect corresponding tooth of *D. indicum* is unknown, I think on the above grounds I am justified in referring the new tooth to that species. This identification is of great importance in connecting the horizon of the Perim Island and Sind rocks as I shall have occasion to note more fully below.

A portion of another tooth of a large *Dinotherium* has been received among a collection made by the late Dr. Verchere, which appears to have come from

[1] P. 397.

Dera Ghazi Khan, and which seems undoubtedly to belong to the same species. The specimen consists of the last ridge of a third upper molar of the left side, but very little worn. Its dimensions are given below, together with those of the second upper molar of *D. pentapotamiæ*, described at page 55 of the second fasciculus of the tenth series of the "Palæontologia Indica," and also with those of the same tooth of *D. giganteum*:—

	D. indicum.	*D. giganteum.*	*D. pentapotamiæ.*
Width of last ridge	3 7	3 4	2 3
Thickness of base of ridge	1 8	1 6	1·1

The new tooth differs from the figured specimen of *D. pentapotamiæ* in having no ledge on the hinder side of the last ridge, and in the ridge itself being somewhat less curved; it agrees with the other teeth of *D. indicum* in having very thick enamel, and being slightly larger than the corresponding tooth of *D. giganteum;* there is a tubercle on the inner side of the transverse valley.

New species of Dinotherium.

In addition to *Dinotherium indicum* and *D. pentapotamiæ,* we have now evidence of a third species of Indian species of the genus. The specimen from which this evidence is derived consists of a portion of the lower jaw, containing the two last molars, collected by Mr. Fedden in Sind. The jaw and teeth are much smaller than those of *D. pentapotamiæ;* the characteristic point of the jaw is, however, its cylindrical form, in which respect it differs from all other species of the genus.

Genus MASTODON.

Of the genus *Mastodon,* Mr. Theobald's last collection contains a great number of specimens of the jaws and teeth, some of which are of great interest, and add considerably to our knowledge of these animals. A few of the most interesting specimens are noticed here cursorily, as it will be a long time before I shall be able to describe them in detail.

Mastodon pandionis, Falc.

The first specimen in this collection which calls for especial notice is a portion of the mandible of a *Mastodon,* which cannot be referred to any of the previously known Siwalik species. The specimen comprises a portion of the horizontal ramus with two molars, and the symphysis of the mandible; the intermediate portion of the specimen was also discovered, but unfortunately crumbled to dust during its transit down country. The most noticeable portion of this jaw is the symphysis, of which the part now remaining has a length of 22 inches; this part is laterally compressed, and on its upper surface is excavated by a large groove upwards of 5 inches in depth at its proximal extremity.

The one complete tooth in this jaw carries four transverse ridges and a hind talon; its length is 8·5, and its width 3·7 inches; this tooth is the last true molar, and the jaw therefore belongs to a *Trilophodon.* The crown of the penultimate molar is unfortunately broken away, but from the small size of its base, I imagine that it could only have carried three ridges. The last molar has a very deep longitudinal valley, which divides each transverse ridge into a distinct outer and inner column; large accessory columns are placed in the valleys, which are in consequence completely blocked. The disks of wear of the columns form irregular circles; the tooth has some resemblance to some varieties of the molars of *M. sivalensis*, in which the alternate arrangement of the columns is less pronounced than usual; the last molar of the latter has, however, five or six ridges. When complete, the distal extremity of the mandible must have been at least 30 inches in advance of the last molar.

There are no tusks in this specimen; among Mr. Theobald's collection, however, there is the distal extremity of an elongated mandibular symphysis of a species of *Mastodon*, which carries portions of two very large tusks. This mandibular rostrum cannot belong to any of the described species of Siwalik *Mastodon;* and as it agrees in form with the last specimen, I consider it probable that both belonged to the same species; the tusked jaw being that of a male, and the tuskless that of a female individual. The fragments of tusks remaining in the specimen are only some 10 inches in length; they are much compressed laterally, the transverse section being pear-shaped, having the thinner end upwards. The inferior border of the fragments is convex, and the superior border concave; the vertical diameter is 3·2 inches, and the transverse diameter at the thickest part 1·11 inches.

Another specimen of the mandible of a trilophodont *Mastodon* broken off at the symphysis, carries two molars, which are respectively the penultimate and last. The second of these teeth agrees precisely with the corresponding tooth of the last specimen of the mandible, but being less worn, is more suitable for description; the identity of these teeth shows that the two mandibles belonged to the same species. The penultimate tooth in the second mandible carries three ridges and a hind talon, which proves that the first jaw belongs to a *Trilophodon.* In these teeth each ridge is divided by a longitudinal channel into an inner and an outer column; each outer column gives off an accessory column from either side, which together project obliquely into and quite block the transverse valleys. The whole arrangement of the columns on the outer side form a zigzag arrangement; while the summit of each column wears into a circle.

Now, the only two known Indian trilophodons are *M. falconeri* and *M. pandionis;* the molars of the former I have not yet been able to describe. The penultimate lower molar of that species is, however, much larger than the same tooth in our new specimens, and has nearly open valleys, with distinct and clear ridges, whose summits wear into trefoils and not into circles. I shall hope shortly to be able to show by a figure the complete distinctness of these two teeth. The jaws of the two are further very different—that of *M. falconeri* being thick and rounded, while the present specimens are thin and flat.

Of *M. pandionis* a description of the penultimate upper molar will be found at page 124 of the first volume of the "Palæontological Memoirs of Dr. Falconer"; if the description of that tooth be compared with that of the corresponding lower tooth noticed above, it will be seen that the two agree precisely, except that one is the reverse of the other, as is always the case in upper and lower molars. I have therefore no doubt but that these new jaws belong to *M. pandionis*, which was consequently a species provided with a long spatulate mandible, and of which the male carried inferior tusks.

The interest of this discovery of *M. pandionis* in the Siwaliks is very great; the other known teeth are said to have been obtained from the Deccan from deposits supposed by Falconer[1] to be of pliocene age; wherever they came from, it is now probable that they belong to the same period as that in which lived the other animals of the Siwalik fauna. In cataloguing the fossil *Proboscidia* in the Indian Museum, I have lately come across a last milk-molar of a trilophodont *Mastodon* from Perim Island which seems undoubtedly to belong to the same species.

In treating of *M. pandionis* at page 124 of the first volume of the "Palæontological Memoirs," Dr. Falconer remarks on the great similarity of the general plan of the teeth of *M. pandionis* and *M. angustidens*, the plan of the former being, however, rather the more complex of the two. It is interesting to observe how this similarity of plan in the structure of the teeth extends into as much as we know of the osteology of the two animals; thus the newly discovered specimens reveal to us that both the species were furnished with a long spatulate symphysis to the mandible, tuskless in the female, but in the male provided with a pair of relatively large and slightly curved tusks. From this similarity in structure we may, I think, infer that these two species of Mastodon were very closely related to one another, and that it is not impossible that at no relatively distant epoch they must have had a common parentage. One very important difference, however, exists in the structure of the teeth of the two species, which is that in *M. pandionis* (though this is not mentioned in Falconer's specimen) there is a large quantity of cement in the valleys, which is entirely wanting in the molars of *M. angustidens*.

MASTODON PERIMENSIS, Falc. & Caut.

Two very interesting points in relation to the dentition of this species are shewn among Mr. Theobald's last collection; one of them is, that this species, like *M. latidens*, was provided with an ultimate upper premolar, and the other that the species carried tusks in the mandible. The specimen proving the existence of an upper premolar consists of a portion of the left maxilla containing two teeth; the hinder of these teeth is 4½ inches in length, carries four transverse ridges, and small fore-and-aft talons; the anterior tooth has not yet come into wear, being only in germ, and having its masticating surface on a level with the base of the crown of the hinder tooth, which proves it to be a premolar, which has only just displaced the milk-molar which it has succeeded.

[1] Pal. Mem., Vol. II, table, p. 14.

The premolar is rounded, and carries two transverse ridges and two small talons. The larger tooth corresponds exactly in form with the first or antepenultimate molar of *M. perimensis* from Perim Island, represented on plate 9 of the first volume of the "Paleontological Memoirs of Dr. Falconer," and which is now in the Indian Museum. Mr. Theobald's specimen is, however, rather the smaller of the two. From the large size of the premolar in the new jaw, I think that that tooth must be the last, and that the tooth which it has replaced must consequently have been the last milk-molar; the second tooth will consequently be the first or antepenultimate true molar, and will correspond to the above-mentioned specimen of Falconer's: the slight difference in size of the two specimens is very probably due to difference of sex.

I have already mentioned at page 71 of the last volume of the "Records" the discovery of a complete mandible of this species, and of the possible occurrence of lower tusks. Two specimens of the symphysis of the mandible of the same species in Mr. Theobald's last collection have now made it certain that certain individuals, probably males, were furnished with small mandibular tusks. Both the new specimens have been fractured, and exhibit sections of the tusks in their alveoli; these tusks were of small size, and show an oval cross-section, of which the vertical diameter in the middle of the symphysis is 1·6 inches, and the transverse diameter 1·3.

PERISSODACTYLA.

ACEROTHERIUM PERIMENSE, Falc. & Caut.

The discovery of a nearly complete cranium of this species in the Siwaliks of the Punjab by Mr. Theobald is of great interest, as only very fragmentary remains of the species have hitherto been known. The new cranium is further interesting, as showing the accuracy of Falconer's opinion (formed on the evidence of a few generally imperfect teeth), that the Perim Island Rhinoceros was hornless, and belonged to the genus *Acerotherium.*

The cranium, with the exception of a few minor injuries, only lacks the extremity of the nasals, and maxillæ and premaxillæ, together with the greater part of the zygomatic arches, to be complete, and is generally in a very excellent state of preservation. As I shall hope on a future occasion to give a figure and a more detailed description of this cranium, it will only be noticed very shortly here.

The cranium is that of a fully adult animal, the permanent molars being greatly worn down, and the cranial sutures mostly obliterated; it is also of huge dimensions. It is at once distinguished from the three species of true Siwalik Rhinoceros, of which figures of the cranium are given in the "Fauna Antiqua Sivalensis" by its straight profile in place of the highly curved profile which characterises the other species. It is further distinguished by the very small size of the nasals: these bones are unfortunately broken off near their base, but sufficient of them remains to show that they formed merely a short conical projection, having no resemblance to the broad and curved bones which occur in the other species. The transverse diameter of the base of these bones in the new cranium is only 3·3 inches, whereas in the smaller crania of *R. sivalensis* and *R. palæindicus* it is 5 and about 4·8 inches respectively, and in the large *R. platyrhinus* is upwards of 6·5 inches. Again, the base of the nasals in the new cranium is perfectly smooth even on the upper surface, shewing that there was no nasal horn, such as exists in the other species; the frontals are also perfectly smooth, and shew no signs of having ever carried a horn. The cranium, therefore, is truly that of an *Acerotherium*, and as such quite distinct from the other Siwalik species of Rhinoceros.

Together with this cranium, Mr. Theobald has sent the less worn upper dentition of another individual of the same species, which is in a better state for comparison than the more worn dentition of the cranium. The antepenultimate upper premolar in both these specimens agrees exactly with the corresponding tooth represented in fig. 15 of plate 75 of the "Fauna Antiqua Sivalensis," which is the type of *A. perimense;* the true molars in Mr. Theobald's specimens also agree with the fragmentary molars of the same species represented on the same plate; the new cranium may, therefore, be safely referred to *A. perimense.*

This being so, the complete dentition of this species now enables me to correct a very serious error into which I had fallen, and through which I had been led to form a new species of Siwalik Rhinoceros, (*R. planidens*), though working with imperfect materials.

If we turn to figures 7 and 8 of the second part of the tenth series of the "Palæontologia Indica," it will be found that I figured two imperfect upper molars of a Rhinoceros, which I considered to be different from the corresponding teeth of any other species, and which I accordingly referred to a new species under the name of *R. planidens.* Subsequently several complete upper molars, and a considerable portion of a mandible, together with an upper incisor, all of large size, were obtained by Mr. Theobald, and were referred to under the same specific name at page 96 of the last volume of the "Records."

Now, the true molars in Mr. Theobald's two latest specimens agree precisely with the above-mentioned upper molars, and clearly belong to the same species. It is therefore clear that the new species *R. planidens* must be merged in *A. perimense.*

In figure 5 of Plate VI of the same volume of the "Palæontologia Indica" I figured two teeth of *A. perimense*, which I considered to be the last premolar and the first true molar, because, as will be seen by the figure, the second of these two teeth is the most worn. Considering this latter tooth to be a true molar, it was apparent that the true molar referred to *R. planidens* could not belong to *A. perimense.* A comparison of the two teeth in question with the dentition of Mr. Theobald's specimens shows, however, that these teeth are really the first and second premolars, and that their relative rate of wear must be an abnormality. I may add that I ought to have known that these two teeth must have been the two middle premolars, because no such discrepancy in size occurs between the last premolar and first true molar as occurs between these two teeth, while the smaller tooth is of too small dimensions to have been the last true molar. I may add that the tooth represented on Plate VI, figure 2 of the above referred to volume of the "Palæontologia Indica," as the first true molar of *A. perimense*, is really the penultimate premolar; and that the unnamed tooth from Sind, represented on figure 6 of the same plate, seems to be the antepenultimate upper premolar of the same species.

On a future occasion I shall hope to be able to give figures of the almost complete upper and lower dentition of the present species; and I cannot but regret that I have previously published figures of such very imperfect specimens. It is interesting to observe that *A. perimense* agreed with the European *A. incisivum*, in being hornless, and in being furnished with a single pair of very large upper and lower incisors, clearly showing that the absence of one weapon of offence or defence is compensated for by the greater development of another.

I may here mention that we seem to be gradually obtaining evidence that the mammalian fauna of the Punjab and Sind forms a connecting link between the fauna of Perim Island on the one hand and of the more eastern Siwaliks on the other. Thus, as will be gathered from a perusal of this and my previous papers in the Records, we have in the Siwaliks of the Punjab and Sind the following Perim Island mammals, which were not known to Falconer from the more easterly Siwaliks, *viz.* :—

Dinotherium indicum. P.; I. P. S.
Mastodon pandionis. P.; I. P. Deccan (?)
Mastodon perimensis. P.; I. P. S. (?)
Hyotherium sindiense. P.; I. S.
Acerotherium perimense. P.; I. P. S. (?)
Hippotherium theobaldi. P.; I. P.

All these mammals belong to old forms, and seem to indicate that the Perim Island deposits and the zone in which they occur in the Punjab (position unknown) are low down in the series and correspond to the older Sind Siwaliks.

Distribution of genera of Siwalik Mammals.

Since the publication of my paper on the "Fossil Mammalian Fauna of India and Burma,"[1] several new genera have been added to these fauna, and the distribution of the previously known genera has been further elucidated. I have therefore compiled the following table of the distribution of the mammalian genera in the Siwalik and the other tertiaries below the Nerbudda group, which must be taken as superseding the tables given on pages 90-92 of my above quoted memoir.

[1] Rec. Geol. Surv. Ind., Vol. IX. pt. III.

Table of distribution in India of Siwalik Mammalian Genera.

Order.	Genus.	Burma.	Sylhet.	Country east of Jhelam R.	Punjab west of Jhelam R.	Sind.	Perim I.
PRIMATES ...	Palæopithecus ...	...	...	×	×	...	...
	Semnopithecus ...	...	...	×	...	...	...
	Macacus	...	...	×	×	...	...
PROBOSCIDIA ...	Dinotherium... ...	...	...	...	×	×	×
	Mastodon	×	...	×	×	×	×
	Stegodon	×	×	×	?	...	...
	Loxodon	...	...	×	...	...	...
	Euelephas	...	...	×	...	...	...
UNGULATA ...	Sus	...	×	×	×	×	×
Artiodactyla ...	Hippohyus	...	...	×	×	...	×
	Tetraconodon ...	...	...	×	×	...	...
	Hippopotamus ...	×	...	×	?	...	...
	Sanitherium... ...	...	...	...	×	...	...
	Listriodon	...	...	...	×	?	...
	Hyotherium... ..	...	...	...	...	×	×
	Anthracotherium ...	...	×	...	×	×	...
	Hemimeryx... ...	...	...	...	...	×	...
	Sivameryx	...	...	...	...	×	...
	Hyopotamus... ...	..	...	...	...	×	...
	Chœromeryx ...	...	×	...	...	...	...
	Merycopotamus ...	×	...	×	×	...	...
	Chalicotherium ...	...	...	×	...	×	...
	Camelus	...	...	×	...	...	...
	Sivatherium	...	...	×	...	...	...
	Hydaspitherium ...	...	...	...	×	...	...
	Vishnutherium ...	×	...	...	?	...	...
	Bramatherium ...	...	...	...	...	...	×
	Camelopardalis ...	...	...	×	×	...	×
	Antilope	...	...	×	×	...	×

Order.	Genus.	Burma	Sylhet.	Country east of Jhelam R	Punjab west of Jhelam R.	Sind.	Perim I.
Artiodactyla — contd.	Bos	?	...	×	...	...	...
	Hemibos	...	...	×	?	...	...
	Amphibos	...	...	×	?	...	...
	Peribos	...	...	×	...		...
	Bubalus	...	...	×	...	...	...
	Bison	...	...	×	...	...	...
	Capra	...	...	×	×	...	×
	Dorcatherium ...	...	...	×	×	...	...
	Cervus	?	×	×	×	...	...
Perissodactyla ...	Acerotherium ...	?	...	?	×	×	×
	Rhinoceros	×	...	×	×	×	?
	Hippotherium ...	...	..	×	×	...	×
	Equus	?	...	×	...	...	...
CARNIVORA ...	Hyænarctos	...	...	×	×	?	...
	Ursus	?	...	×	...	...	...
	Mellivora	...	...	×	×	...	...
	Meles ?... ...	...	...	...	×	...	...
	Amphicyon	...	...	×	×	×	...
	Enhydriodon ...	...	.	×	..	...	...
	Lutra	...	...	×	×	...	...
	Canis	...	...	×	?	...	...
	Ictitherium	...	...	...	×	...	...
	Hyæna	...	...	×	×	...	...
	Machairodus... ...	...	...	×	...	...	...
	Felis	...	...	×	×	...	...
	Pseudælurus... ...	...	...	...	×	..	...
RODENTIA ...	Hystrix	...	...	×	×	...	...
	Rhizomys	...	...	?	×	...	...
	Mus	...	...	×	...	...	...
EDENTATA ...	Manis	...	...	...	...	×	...

In the above table there are a few points which call for short notice. In the first place, the number of specimens collected from Sylhet is so small, that no inference as to the absence of genera from the formations of that district can be drawn from their absence in the table: to a less degree the same remark applies to Burma and Perim Island. Again, in the three columns headed respectively Country east of Jhelam R.," "Punjab, west of Jhelam R.," and "Sind," I do not wish to lay any great stress on the absence in any of these columns of any of the rarer genera, such as *Sanitherium*, *Amphicyon*, or *Lutra*, as indicating their absence from the formations under those columns. On the other hand, the presence or absence in any of these columns of any of the common genera, such as *Euelephas*, *Merycopotamus*, *Bos* or *Equus*, is of great weight, and is to be considered in many cases as a fact in distribution.

We may notice in Sind the complete absence of the following common Siwalik genera, *viz.*, *Stegodon*, *Loxodon*, *Euelephas*, *Hippopotamus*, *Merycopotamus*, *Camelus*, *Camelopardalis*, *Bos*, *Bison*, and *Equus*; and we may further note that most of these genera are modern forms, and that most of them are not found in the country to the west of the river Jhelam, but that they occur commonly enough in the country to the east of that river. Again the genera *Dinotherium*, *Listriodon*, *Hyotherium*, various Suina, *Hyopotamus*, and *Acerotherium*, are of fairly common occurrence in Sind and the Punjab, and do not, I believe, occur in the country to the east of the Jhelam, with the exception perhaps of *Acerotherium*, which has been found a little to the east of that river. Again the genus *Equus*, which is extremely common in the Siwalik country of Falconer, is unknown in the Western Punjab, and is there replaced by *Hippotherium*, of which genus at least two species occur there very commonly, of which one *(H. artilopinum)* occurs in the more eastern country, while the other *(H. theobaldi)* is only known from the Western Punjab and Perim.[1]

The table in fact shows that the more modern genera are mainly characteristic of the country to the east of the Jhelam, while the Punjab, Sind, and Perim Island are characterized by an older facies of genera,—the greater number of old genera occurring in Sind. The Sind fauna is consequently to be regarded as the oldest of the Siwalik group, that of the Punjab and Perim Island probably the next in age, and the Siwaliks of the Dehra Dún and neighbouring country as the newest of all. I wish, however, to add that although I think the difference in the mammalian faunas of the different districts under discussion are due in great measure to differences in relative age, yet that it is probably that many of the genera, such as those of the *Sivatheridæ*, were strictly contemporaneous, and were limited in their geographical range.

[1] In Falconer's catalogue of the *Vertebrata* in the collection of the Asiatic Society of Bengal, the molars of this species are referred to *Equus*. I believe I have evidence of the existence of four species of the genus in the Púnjab.

DESCRIPTION OF PLATE.

Fig. 1. PALÆOPITHECUS SIVALENSIS, nobis.
Lateral view of right maxilla.

" 2. MACACUS SIVALENSIS, nobis; palatal view of right maxilla.

" 3. RHIZOMYS SIVALENSIS, nobis; palatal view of left ramus of mandible.

" 4. MACACUS SIVALENSIS, nobis; palatal view of left maxilla.

" 5. PALÆOPITHECUS SIVALENSIS; palatal view of specimen represented in fig. 1.

Fig. 3 twice the natural size; the rest natural size. The two sides of the maxilla represented in fig. 5 have not been placed quite symmetrically. The perfect tooth on the left side of the figure should be opposite the decayed tooth on the right side.

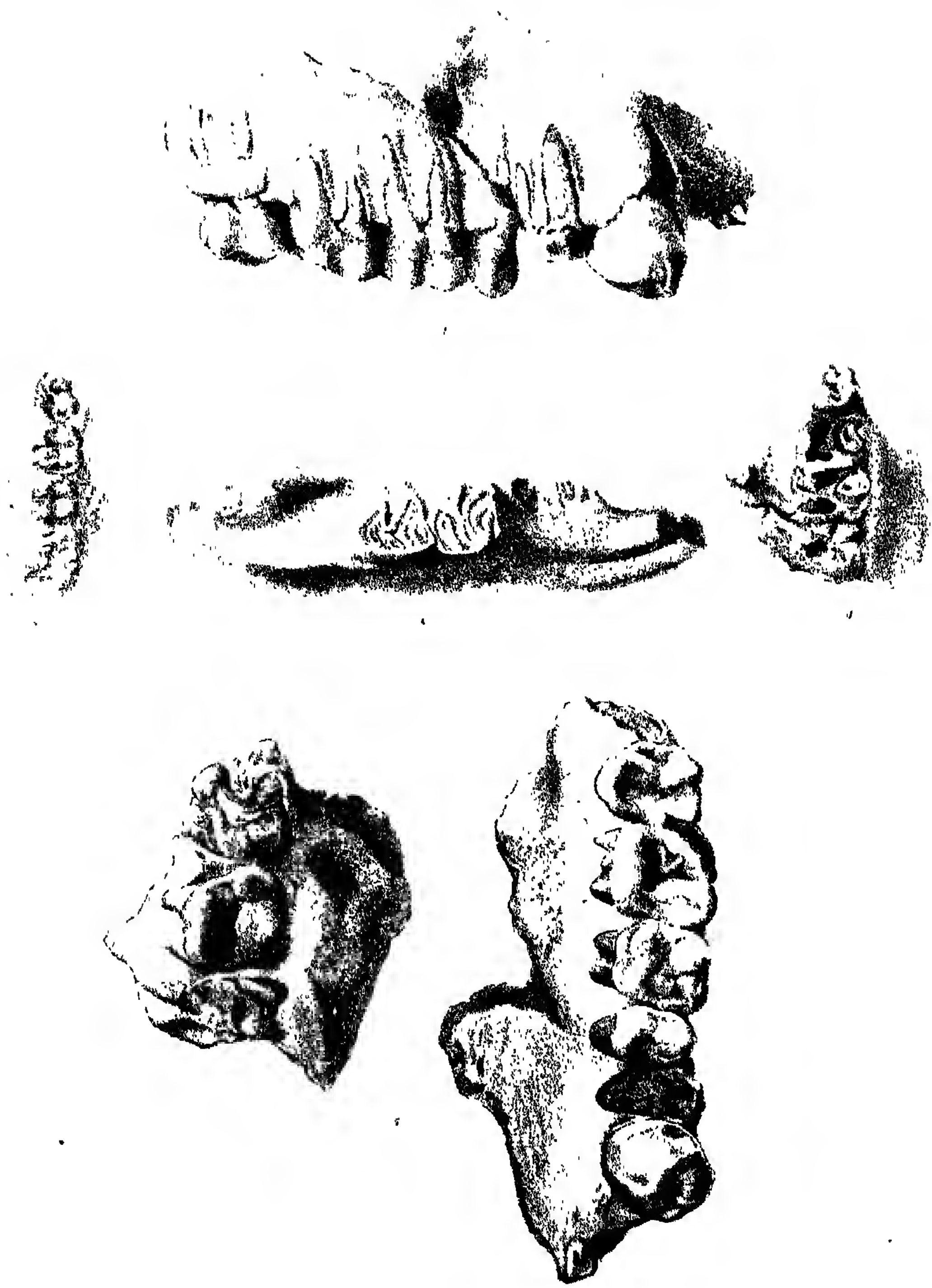
NOTES ON SOME SIWALIK BIRDS, *by* R. LYDEKKER, B. A., *Geological Survey of India.*

INTRODUCTION.

In the Siwaliks, as in many other ossiferous formations, the fossil remains of birds are of extremely rare occurrence, and such bones as do occur are generally, owing to their delicate structure, merely fragments of the stouter extremities. Except in formations like the lithographic slates of Solenhofen, the skull of birds are scarcely ever preserved as fossils, and none have as yet been obtained from the Siwaliks. From time to time, however, a few fragments of bird-bones have been obtained from these deposits, and these are of extreme interest, as being the only evidence we have at present of the existence of an avian fauna in the Siwaliks. Some of these bones were collected by Dr. Falconer, and were deposited by him in the British Museum, figures being given of them on Plate R of the unpublished plates of the "Fauna Antiqua Sivalensis."[1] On the evidence of these bones M. A. Milne-Edwards[2] established two species of extinct Siwalik birds, namely, *Struthio asiaticus* and *Argala falconeri*. From the evidence of another bone which is not figured in the "Fauna Sivalensis," the same writer considered, that a bird allied to *Phaëton* must have lived with the Siwalik fauna.

Among the vast collection of mammalian and reptilian bones obtained by Mr. Theobald from the Siwaliks, there are a few fragmentary bird bones; and these together with the bones collected by Dr. Falconer, form mainly the subject of the following short notes. These notes are not intended as an accurate description of the bones, because I wish to defer that description in the hope that I may hereafter obtain more complete materials. Some of the bones are, however, of such interest, that I have thought it well to bring their existence into notice, without deferring them to the indefinite period when I shall be enabled to give figures of them.

[1] Photographic copies of these plates can now be obtained at the British Museum.
[2] Oiseaux fossiles de la France, Vols. I, p. 449, II, p. 587.



FOSSIL STRUTHIOIDS.

With regard to *Struthio asiaticus* of M. Milne-Edwards, it appears that this species was formed on the evidence of the phalange, and of the distal extremity of the tibio-tarsus, which are represented in figs. 2 and 15 of the above-quoted plate of the "Fauna Antiqua Sivalensis." In noticing these species, M. Milne-Edwards (*loc. cit.*) remarks: " *L'une des espèces les plus remarquables appartenait au groupe des Brévipennes et se rapprochait beaucoup de l'Autruche d'Afrique par la conformation de son pied, qui ne portait que deux doigts.*" I am rather at a loss to discover how M. Milne-Edwards determined that his Siwalik ostrich had but two toes, because, as I have said, the only struthioid bones figured in the "Fauna Antiqua Sivalensis" are the distal extremity of the tibio-tarsus and a phalange. The first bone would, as far as I am aware, give no indication of the number of toes, and the second, which appears to belong to a median digit, is symmetrical in itself, and might, as far as I can see, belong to either a two- or a three-toed bird. It is, however, possible that M. Milne-Edwards may have seen a specimen of the tarso-metatarsus of this struthioid which would of course settle the question. In any case it is probable that such an authority on the subject as M. Milne-Edwards would not have made such a positive assertion without good grounds; and I therefore adopt his *dictum*, that the bird to which the two above-mentioned bones belonged was a two-toed ostrich.

I now come to four bones of a large species of struthioid, collected by Mr. Theobald in the Western Punjab. These bones comprise two specimens of the first and second phalanges of the outermost digit[1] of a three-toed struthioid bird; one pair of these bones is somewhat larger than the other pair. I will not describe these bones on the present occasion, but will content myself with saying that as regards form, they agree almost precisely in form with the corresponding bones of *Dromæus novæ-hollandiæ*.

The dimensions of the four fossil bones and the two corresponding bones of *D. novæ-hollandiæ* are as follows, in inches:—

	Large fossil.	Small fossil.	*Dromæus novæ-hollandiæ.*
Length of first phalange	2·4	2·3	1·8
Antero-posterior diameter of superior surface of ditto ...	1·36	1·25	0·75
Transverse ditto	1·3	1·2	0·7
Antero-posterior ditto inferior ditto	0·9	0·7	0·46
Transverse ditto	1·0	0·8	0·6
Length of second phalange	1·5	1·3	0·8
Antero-posterior diameter of superior surface of ditto ...	1·1	0·95	0·55
Transverse ditto	1·3	1·1	0·62
Antero-posterior ditto inferior ditto	0·7	0·65	0·45
Transverse ditto	1·3	1·1	0·54

[1] Corresponding to the fourth of the typical series.

It will be seen from the foregoing measurements that the fossil and recent bones bear the same relative proportions, and that the larger fossils are almost exactly double the size of the recent bones. The difference in the size of the fossils does not appear to be greater than that which might occur in different individuals of the same species. There are some very slight minor differences between the fossil bones and those of *Dromæus novæ-hollandiæ*, but they do not appear to me to be more than of specific value; and I think that the fossils should undoubtedly be referred to that genus.

It may be well to observe, that the outermost digit of *Struthio* has its phalangeal bones of a much more slender type than those of *Dromæus*, and each bone is more nearly symmetrical in itself than in the latter genus. The stout and obliquely shaped fossil bones cannot therefore belong to *Struthio.*

Had it not been that M. Milne-Edwards had referred the struthious Siwalik bones in the British Museum to the two-toed genus *Struthio*, I should have not improbably referred all the bones to one species. The tibio-tarsus of *Struthio asiaticus* is, however, rather small for the fossil phalanges. For the three-toed Siwalik struthioid bird I propose the name of *Dromæus sivalensis.* If it should turn out eventually that M. Milne-Edwards was erroneous in referring the struthioid tibio-tarsus to the genus *Struthio*, and that that bone really belongs to a three-toed species, then it may possibly belong to *Dromæus sivalensis*. Irrespective of this question, however, the new fossil bones afford us indisputable evidence of the former existence in India of an emeu of double the size of the existing emeu of New Holland, and which must have rivalled in size some of the gigantic fossil three-toed wingless birds of New Zealand.

If we accept M. Milne-Edwards' *Struthio asiaticus*, it is clear that the ostriches of Africa and the emeus of Australia once had a common home on the plains of India, and it is possibly from this common home that they have gradually spread, till they are now isolated from one another on opposite sides of the globe.

The living faunas of India and of the Australian region are almost totally distinct; but there are a few indications in Celebes and some of the neighbouring islands of there having been a former communication between the African Oriental, and Australian faunas; and it is probable that the same means of communication afford a passage for the *Struthionidæ*. Mr. Wallace,[1] in explanation of the supposed communication, suggests that a large tract of land formerly extended from Australia in a north-westerly direction to Asia, and that this old land was probably the home of the ancestors of *Sus*, *Babirusa*, *Phacochœrus*, *Anoa*, *Bubalus*, *Cynopithecus*, *Cynocephalus*, and *Macacus*, to which we may now probably add *Dromæus* and *Struthio*.

Since the emeus and cassowaries are not found fossil in Australia or New Guinea, while numerous fossil species of marsupials occur throughout these islands, and since struthioids are known to have existed in the older pliocene (or

[1] Geographical distribution of Animals, Vol. I, p. 437.

upper miocene) in Asia, while the marsupials (with the exception of the *Didelphidæ*) have not been known out of Australasia since the Eocene period, it is not impossible that the struthioid birds are a much later introduction into Australasia than the marsupials. At page 340 of "Tropical Nature," Mr. Wallace says that Australia was isolated during the whole of the tertiary period, and on the next page that it has not improbably been isolated since the oolitic period. If I am right in referring the fossil Siwalik bird-bones to *Dromæus* (and they are certainly closely allied) we have indications of a much later connection between India and Australia.

NEW WADER.

The next fossil bird-bones I wish to notice are an associated sternum and an incomplete tibio-tarsus of a gigantic carinate bird, which probably belonged to the order Grallatores; though it presents certain peculiarities which appear to distinguish it from all other living birds. This sternum and tibia were in the collection of the Asiatic Society of Bengal, and were marked in Dr. Falconer's handwriting as having been obtained from the Siwaliks, though no locality is mentioned. The sternum has a bold convex carina, and has a considerable general resemblance to the sternum of *Argala* (*Leptoptilus*); the notch on either side of the xiphi-sternum is, however, much deeper and larger, and the xiphi-sternum itself larger and longer. The sternum is moreover more expanded laterally than in *Argala.* The peculiarity of this sternum, however, is that the distal half of the furculum, which alone remains, is completely anchylosed to the superior border of the sternum, so that no trace of division is visible. Behind this anchylosed furculum are the long coracoidal grooves, which are placed much more backwards than is usually the case in birds. I do not know of any instance among living birds of such complete anchylosis of the sternum and clavicles, such anchylosis being usually confined to the hypocleidium of the furculum and the manubrium sterni. The fossil sternum is of considerably larger size than that of *Argala indica*, but from its general form seems clearly to have belonged to a bird allied to that genus. The tibio-tarsus which was associated into the sternum lacks its distal extremity (astragalus), as well as some portion of its proximal extremity.

The fibula is anchylosed to the upper half of the tibia, which shows that the bones do not belong to a struthioid, in which the tibia and fibula are distinct. The bone has the general shape of the tibia of *Argala*, but is flatter superiorly, and, in place of being slender, is stout and strong like the tibia of the ostrich. The length of the imperfect tibia is about 14 inches, while its transverse diameter superiorly is 1·8 inches, and its antero-posterior diameter 1·2 inches.

As regards size, our tibia has a great resemblance to the gigantic *Gastornis parisiensis*[1] of the French eocene, which is only known by its femur and tibia, and which seems to have characters common to the Grallatores and Natatores. The tibia of *Gastornis*, however, expands inferiorly, whereas the Indian bone contracts: there is also a great hollow in the former on the anterior surface above

1. Oiseaux fossiles de la France, Atlas, Vol. II, pl. 29.

the condyles, which does not occur in the latter. In *Gastornis* the tendon of the *tibialis anticus* muscle passes through a distinct bony arch, which I think does not exist in the Indian fossil. Again, the Indian tibia has the fibula anchylosed to it for half its length, which is not the case in *Gastornis*. I am not aware of any other living or fossil bird (except the *Ratidæ*), which has a tibia approaching in size to that of our fossil.

These two bones indicate the former existence of a carinate bird, probably allied to the adjutant, but which in stoutness and length of limb was intermediate in size between the ostrich and the emeu. I propose to call this bird *Megaloscelornis sivalensis*[1]; the remains I hope to describe more fully on a subsequent occasion.

Argala falconeri, M.-Edwards.

The remains of *Argala falconeri* in the British Museum, according to M. Milne-Edwards (*loc. cit.*), consist of the proximal and distal extremities of a tarso-metatarsus, and two specimens of the distal extremity of the tibio-tarsus. Two of the bones indicate a bird larger than *Argala indica* (*Leptoptilus argala*), while the other two are of somewhat smaller size. In the Indian Museum we have three bones belonging to *Argala falconeri*, all of which were collected by Mr. Theobald in the Punjab: these bones comprise a very late cervical vertebra,[2] the distal extremity of a tibio-tarsus, and the first phalange of the outermost digit. The first two of these bones are of exactly the same size as the corresponding bones of *A. indica*, while the third is slightly smaller: as regards form all appear to me to be indistinguishable from the corresponding bones of the living species. Since some of M. Milne-Edwards' specimens are of somewhat larger size than the living adjutant, it is evident that the Siwalik adjutant attained a somewhat greater size than the living species; but as the bones of the two are indistinguishable in form, it appears to me to be very doubtful whether we have as yet any good evidence as to the specific distinctness of the living and fossil forms.

CONCLUSION.

Besides the above-described bones, there are in the Indian Museum a cervical vertebra and a tibio-tarsus of birds about the size of the common fowl, but whose affinities I have not yet determined.

There is also the distal extremity of the femur of a large unknown bird figured in the "Fauna Antiqua Sivalensis," as well as several fragments of bones of smaller birds. In the collection of the British Museum there is the distal extremity of the humerus of a large bird, which was recently discovered among some Siwalik specimens by Mr. Davis, who showed it to me; but I had then no opportunity of determining to what bird it belonged. It will be noticed that among these Siwalik bird-remains, those of *Argala falconeri* are the most common, and that the great majority of the known bones belonged to birds of large size.

[1] μεγας-αλος, σκέλος, ὄρνις.

[2] Rec. Geol. Surv. India, Vol. IX, p. 104.

This, I think, can only be accounted for by the larger bones being, firstly, more likely to escape destruction, and secondly, being more likely to be obtained by collectors. We are not therefore, from the paucity of small bird-bones, to argue that the smaller birds were not fully represented in the Siwalik fauna, any more than in the case of the small mammals, of which the remains are likewise extremely rare. Since birds, as a rule, are of far inferior size to mammals, it is only natural to expect that the discovered fossil bones of the former should only present a very small percentage of those of the latter.

With regard to the Siwalik tarso-metatarsus stated by M. Milne-Edwards to indicate a bird closely allied to the living Tropic birds (*Phaëton*), it seems incredible that a bird of that essentially oceanic genus could have lived in the land-locked Siwalik country. The difficulty may perhaps be got over by calling in question the authenticity of the locality of the bone, of which there seems no certain history.

NOTES OF A TOUR THROUGH HANGRANG AND SPITI, *by* COLONEL C. A. MCMAHON.

Circumstances over which I had no control delayed my departure from Simla so long, that the time at my disposal was only sufficient to enable me to make road-side observations by the way. I could only devote one halt to explorations off the road.

In my last paper (Rec. Geol. Surv., X, p. 204) I described the rocks of the Upper Sutlej as far as Jangi, and I now proceed to describe the section from that place to Spiti, *viá* the Ruhang and Hangrang passes.

The dip of the schists and central gneiss between Pangi and Jangi varies from north-east to east-north-east. Between these places, as described in my last paper, frequent intrusions of granite culminate in an eruption on a grand scale; the granite constituting the core of the Gongra ridge, and extending in a north-westerly direction from near the confluence of the Todoong Gar river with the Sutlej, to Lepi. Whether it extends beyond Lepi I do not know. The rocks fringing this central granitic core, and forming the minor ridges of the Gongra range, are mica schists. On leaving Jangi (elevation 8,850 feet)[1] the dip is at first flat, but as Lepi (elevation 8,880 feet) is neared, a west-south-west dip is set up. Between Lepi and the top of the Ruhang pass (elevation 14,354 feet, T. S.) the dip varies from north-north-east to north-west. The rocks, which at first are silicious and micaceous schists, gradually get more and more slaty, and finally pass into unmitigated slates with a grey streak.

Whether there is a gradual transition from metamorphic crystalline rocks to clay slates—the one gradually passing into the other—or whether the transition is merely apparent, I cannot positively state. It would require, I think, a careful detailed survey of the ground to decide the question definitely. It is impos-

[1] The elevations given are generally those shown by my aneroid barometer: when the trigonometrical survey elevations are given, the letters T. S. are affixed.

sible for a Himalayan traveller, with a long and toilsome march before him, to crack *every* piece of rock he sees, and scrutinize it minutely; and when rocks on their weathered surface give no outward indication of a change, it would be quite possible, I imagine, to miss the border line between slaty micaceous or slaty silicious schists on the one side, and micaceous or silicious slates on the other. The difficulty is increased not only by the fact that some metamorphic rocks in this area closely resemble in external appearance the sandstones and slates of the palæozoic series in contact with them, but also from the circumstance that both series have been alike affected by comparatively recent disturbances.

I have no note of any granite veins, and I feel sure I did not see any in the schists at Lepi. I see no reason to suppose that the intrusion of the Gongra granite (which I believe to be albite granite) occurred at a later period than the albite granite of other sections; and I do not, therefore, think that the metamorphism of the schists at Lepi can be explained by referring it to the rise of the granite.

At the top of the Ruhang pass the dip changes to south-south-west, and the angle of dip is high all the way down to Sungnam (elevation 9,520 feet). The rocks resemble the slates and fine sandstones of the Simla slate series.

At Sungnam, the slates, which are here nearly perpendicular (dip extremely high to west-by-south), are of a light grey color; but on the way up the Hangrang pass they get darker in color, and become like the Simla slate beds that so much resemble some of the nummulitic clays. At an elevation of 10,150 feet, the northerly dip is recovered by a sharp and fractured anticlinal, along which some of the beds above, dipping north-east, seem to have been pushed over the beds on the south-west side of the anticlinal.

At an elevation of 11,050 feet, the slates terminate suddenly, their junction with the rocks above them being masked by a side stream, running down from the top of the Hangrang pass. On the other side of this stream, pink limestone appears, in beds of from 1½ to 2½ feet in thickness. There are probably from 300 to 400 feet of them.

When first seen the pink limestones apparently dip north-north-west, but this rapidly subsides into a north-east-by-north dip. These beds are overlaid conformably by purple calcareous indurated clays that break under the hammer into lumps, and not into slaty slices. Over these is a small outcrop of a slate with a dark streak, which is overlaid, at an elevation of 12,000 feet, by a thin bed of dark-blue limestone. Then follow, in the ascending order, dark slates that break into acicular fragments. They reminded me so much of the argillaceous beds exposed on the eastern side of the Krol mountain[1] that it needed the test of acid to satisfy me that they were not calcareous. At an elevation of 12,300 feet these slates give place to dark-blue compact limestones, for the most part in beds of half a foot to two feet in thickness, and they continue up to the top of the pass (elevation 14,530 feet). A bed of greenstone occurs in them.

[1] Mem. G. S. I., Vol. III, pt. 2, p. 24.

Judging from the talus, I am under the impression that the rocks on the south-east side of the pass, namely, in the direction of the Thagiriga trigonometrical station, consist of slates faulted against the limestones; but I had no time to scale these cliffs to examine them. On the north-west side of the pass, and down to Hango (elevation 11,500 feet), the limestones continue; the north-easterly dip changes near the summit of the pass to a low west-north-west dip, producing, when the beds are viewed from below, an appearance of unconformity.

On the descent, at an elevation of 13,400 feet, clay slates re-appear, dipping south-west. From this point, owing to great contortion, the limestones and slates alternate several times, being sometimes perpendicular, at others dipping south-south-west. Near the bottom of the descent, a compact quartzite becomes prominent, sometimes perpendicular, sometimes dipping south-west-by-south, In color it varies from a bluish to a pinkish-white. Close to Hango, as another result of contortion, the thin-bedded limestones and slates re-appear, having an extremely high (nearly perpendicular) north-east dip.

The quartzites above described and the thin-bedded limestones at the top of the pass belong, I apprehend, to the Krol formation. I doubt if hand specimens could be distinguished from those taken from the Krol mountain itself. Most of the beds weather a dark blue, but some brown. The rock abounds in white calcite markings, similar to those so common in typical Krol rocks. The purple calcareous clays I have described as occurring on the south side of the pass reminded me of the purplish-red, sometimes calcareous clays of the Krol and Boj.

Proceeding onwards towards Leo on the Spiti river, the first rock seen on leaving Hango, and which dips north-east, is a highly silicious white limestone (weathering white) with a faint shade of green in it, due apparently to the presence of a little chlorite. On the weathered surface I saw what looked like a cast of *Nautilus spitiensis*, only about half the size of that figured in Plate IV, Memoirs vol. V, as one of the Lilang fossils. It seemed to vanish into nothing when examined with the aid of a lens, and broke into pieces on the first application of the hammer, leaving me in a painful state of doubt whether I had seen a real fossil or not.

The limestone just described is overlaid by a hard silicious dull pinkish-white limestone that weathers a dull red-brown. It might easily be taken for a quartzite, but it effervesces slightly with acid (strongly when powdered), and a qualitative analysis of it shows that it contains a good deal of lime and some magnesia. A thin slate is intercalated with these limestones. There are some hundreds of feet of these rocks, but I cannot say exactly how thick they are, as the hill side is obscured by talus for some miles. The reddish-weathering limestone appeared, from blocks that had fallen down, to be overlaid by a bluish-white quartzite.

As I journeyed onwards the north-east dip appeared to flatten and then to change temporarily to east-south-east, the change of dip bringing down to the road dark-blue limestones resembling those at the top of the Hangrang pass.

The white limestones at Hango are, I apprehend, the same rocks as the pink limestones on the south side of the pass.

Further on, at a point where the road, having rounded a spur, winds into the mountain side, slates re-appeared dipping west. As the silicious limestones did not crop out between the blue limestones and the slates, I presume they were hidden by the talus, which, at the level of the road, is very abundant along this section. As the crystalline series was neared I came to a pale bluish-white slate weathering a bright yellowish ochre color in irregular patches. Associated with the latter was a thin bed of dark slate, in some places as black as coal

From these rocks I passed by a sudden transition to the crystalline series. The change takes place just where the road from Hango rounds the edge of the Tinga ridge, at an elevation of 11,500 feet, before the commencement of the descent to Leo. The slates rest upon the crystalline rocks, and no material change of dip would be observed in passing from the one series to the other.

The crystalline series extends from the point indicated up to (and probably beyond) the Para river, but at and beyond Chango, as will be shown further on, they are overlapped by pink limestones and calcareous slates. The lowest beds in the crystalline series at Leo are massive quartzites; these are followed by thin-bedded white and bluish-white quartzites, with some beds of mica schists. Higher up in the series the mica schists become more prominent. Some of the latter are fine-grained silicious rocks, showing no mica on the weathered surface.

The crystalline rocks, quite up to their junction with the unaltered rocks, are riddled through and through by dykes and veins of albite granite, varying in thickness from about 30 feet to the fraction of an inch. The granite is undoubtedly intrusive. It may be seen throughout the crystalline series between Leo and Chango, from the bed of the Spiti river up to the tops of the highest peaks, profusely penetrating the strata in all directions; sometimes darting across them in long zigzags, like forked lightning; at others, following the line of bedding for some distance, and then either dwindling away into thin strings, or terminating suddenly to burst out in adjacent strata with redoubled force.

The granite in the gneiss in the vicinity of Chango has already been identified as albite granite (Memoirs, vol. V, p. 154). It presents all the characteristics of the intrusive albite granite of the Wangtu section of the Sutlej valley, being a mixture of quartz, muscovite, schorl, and a snow-white felspar (*occasionally* showing triclinic striations) that scarcely weathers at all. When the schorl is sparsely scattered through the rock, the muscovite is plentiful and in good sized packets or leaves, but when the black tourmaline is abundant, the muscovite becomes very subordinate and dwindles to thin flakes of small size. In some places the schorl is profusely scattered through the rock, in irregularly shaped fragments.

Near Chango I found cyanite in mica schists. It was of beautiful cobalt blue, shading into a pearly white, but the blades were not nearly so large as those of the mineral found in the central gneiss near Wangtu. In the same locality there were some chiastolite schists near granite.

I first met with gneiss within a few miles of Chango. It showed again between the latter place and the Para river, and on the banks of that stream. Dr. Stoliczka identified the gneiss on the left bank of the Para river as the *central gneiss* (Memoirs, vol. V, p. 16), and though I saw none porphyritic in structure, I do not doubt the correctness of the identification. That the crystalline rocks I have described belong to the central gneiss series may, I think, be accepted on the evidence of their crystalline structure, and the presence in them of cyanite and intrusive albite granite, characteristic features of the typical Wangtu section. The dip of the crystalline rocks at Leo is west-by-north, but this changes gradually to west-south-west, and finally at Chango to south-west.

About two miles south of Chango a ridge of limestone rocks, the dip of which varies from south-west-by-south to south, runs up from the Spiti river and abuts on the crystalline series just where the road from Leo to Chango crosses the ridge. At this point the dip is south-west-by-south. The limestones consist of thin-bedded, pale blue and cream-colored beds, weathering from a pale pink to a yellow ochre color, intercalated with dark blue calcareous slates. The latter effervesced freely with acid wherever I tested them, but they break up into small thin slices, and look more like slates than limestones.

In a cliff overhanging the Spiti river, I found what appeared to be coralline remains in the pale blue limestone; but they were in bad preservation and have not been identified.

In the bed of a stream to the east of Chango and between the latter village and the ridge above described, and also at the village of Chango itself, some hard dark slates are exposed. Dr. Stoliczka also mentions (Memoirs, vol. V, p. 19) the occurrence of silurian slates opposite Shalkar. The slates dip under the limestones.

On the north side of Chango the limestones distinctly overlap upon the crystalline series. To the north-east of the village, where two irrigation channels "take off," as engineers say, from the stream flowing down from between the Kakthai and Kungrang trigonometrical stations to the Spiti river, the crystalline series is to be seen in contact with the pink limestones and dark calcareous slates. The mica schists are riddled with albite granite veins up to the point of contact.

The limestones overlap the schists; and though the plane of contact dips at a high angle, the junction of the two series of rocks is evidently not a faulted one, for about a mile lower down the stream, the crystalline series again crops up and forms a cliff overhanging the river; the identity of these rocks here with those higher up the stream being established by the presence of two albite granite veins in the cliff alluded to. Further evidence of the fact that the limestones overlap the crystalline series was obtained as I journeyed onwards along the line of strike.

From Chango (elevation 10,15C feet) up to the top of the Chandan Namo ghat[1] (elevation 12,340 feet), the rocks consist of similar limestones to those

[1] Marked Ga station on the map. It is opposite Shalkar.

described as occurring in the ridge south of Chango; in both ridges white and grey quartzites occur in connection with them; but the whole hill-side is covered with talus, and only little outcrops of rocks *in situ* are seen here and there. The pink limestones at the commencement of the ascent dip north-north-east and north-by-east, but the dark calcareous slates are generally vertical or dip about in all directions. At the bridge over the Chadaddokpo the crystallines (mica schists and gneiss well riddled with albite granite as usual) re-appear in force on both banks of the stream. They appeared to extend a considerable way down the stream. Dip here north-west by-west. On rising from the bed of the river I came again to unaltered whitish blue limestones, whilst beyond, in the same line of strike, the mica schists and granite re-appeared. In the bed of the Para river the gneiss is so riddled with granite that its metamorphic character is nearly obliterated.

Proceeding westwards from the camping ground on the banks of the Para river (elevation 10,580 feet) the rocks are at first white quartzites dipping east-by-south; then follow compact blue slaty limestones, and then a pale salmon pink limestone weathering a light ochre brown. The blue beds break up into thin slaty slices, and the whole, no doubt, are a continuation of the beds seen at Chango. They continue over the ridge down to the Ghu river. As the stream is neared the white quartzite seen on the banks of the Para re-appears, dipping east-north-east and north-east-by-east. It weathers a reddish-brown. Below it are grey quartzites, and below the latter, in the bed of the stream, is a pale whitish-grey slate sufficiently soft for a knife to cut well into it.

The pink limestones and calcareous slates in contact with the crystalline series at Chango are, I apprehend, identical with the pink limestones and slates seen at Hango; but I feel some difficulty at present in giving a name to them. They are above the silurian slates (overlapping them and resting on the crystallines at Chango), and are overlaid by the dark Lilang limestones at the Hangrang pass and Hango. They appear to occur again, as will be mentioned further on, in the same order, between Losai and the Kanzam pass. I think they answer best to the Muth middle beds, which Dr. Stoliczka correlated with the Blaini limestone of the Simla area (Memoirs, vol. V, p. 141), and in coloring the accompanying map, I have provisionally classed them as Muth middle beds. Very often both the weathered and fractured surfaces of the pale blue and pink limestones reminded me of the Blaini limestone of the Simla area

I considered it right to note (page 59) that I saw at Hango what had the resemblance of a triassic fossil, but unless and until other triassic fossils are found in the pink limestone beds, I do not think it would be safe to attach importance to the circumstance.

Proceeding onwards towards Huling, the road leads over what appears to be a continuation of the same series for a short distance, when these rocks are suddenly cut off, apparently by a fault with no great throw; the road, which follows the line of strike, passing suddenly from white quartzites to silky slates containing some beds of very pale blue limestones (both weathering reddish-brown), being the beds of the Bhabeh series described by Dr. Stoliczka at p. 19, vol. V, Memoirs.

These rocks at first dip north-west, but eventually round to west-by-north; the change being marked by a great contortion amongst the upper rocks on the left bank of the Spiti. The silky slates are succeeded by rocks higher in the series; those described at p. 20 of Dr. Stoliczka's Memoir, *viz.*, beds of light colored quartzites and quartzite sandstones intercalated with dark slates that splinter into small thin slices. The debris of these slates imparts a very dark tint to the mountain sides, especially when seen from a distance, but whenever I tested them I found that they had a pale grey streak.

These beds on the Spiti river, between Huling and Po, have the same coloring in the accompanying map as the slates south of Leo and of the Kanzam pass; but in both of these latter regions they more closely resemble the slate series of the Simla area; and I was unable to decide from the cursory survey of the rocks along the route I followed, whether the difference in the character of the beds is due to alteration in their lateral extension, or whether they occupy a different horizon in the palæozoic series. From Dr. Stoliczka's remarks at page 21 of his Memoir, he would appear to have held the former view, and I think it is probably the right one, but the point can only be satisfactorily determined by the survey of a wider area than I had an opportunity of visiting.

Near Lari the strata become vertical for a short distance, and here I observed a thick bed of the contemporary greenstone described by Dr. Stoliczka as occurring in the palæozoic formation of Spiti (Memoirs, vol. V, p. 20). For some distance beyond Lari, angular blocks of this rock on the road side attested its presence in the cliffs above, but if it again dip down to the level of the roads, the outcrop must be buried under talus, as I did not see the rock *in situ* again.

From Lari onwards I did not observe any material change in the character of the rocks until nearing the point where the river Spiti takes a sudden north-west turn near Mani.[1] Here the strata suddenly dipping down to the river and rising on the opposite side form a sharp synclinal, along the axis of which the Spiti river runs for many miles. To the south-east the synclinal can be seen dying out among the peaks overhanging the Manirang pass, whilst to the north-west it may be traced for about ten miles beyond Dhankar, the bottom of it rising higher and higher and fading away in the mountains on the right bank of the Spiti.

This sharp bend in the strata brings down the upper rocks, and amongst them I observed a conglomerate, in a cliff overhanging the road on the left bank. There is about 40 feet of it. The matrix is a brown slaty rock; and it contains numerous pebbles of white, grey and reddish quartzite of irregular, rounded and subangular shapes. The largest I saw was about 4 inches in diameter.

This rock resembles the Blaini conglomerate of the Simla area. On the conglomerate rests a limestone containing numerous fossils, but in such bad preservation that none have been clearly identified. This was followed in the ascending

[1] Mani is on the right bank below Dhankar.

order by a brown sandstone which doubtless belongs to Dr. Stoliczka's carboniferous series Then came talus, then slates followed by limestones interbedded with slates, and finally massive blue compact limestone (Lilang), weathering blue and brown in irregular patches.

The Lilang limestones which are exposed from this point almost the whole way up the valley are very like typical Krol rock. In color, in the thickness of their beds, and in often containing tortuous white calcite markings, they much resemble the rocks of that series. As I have described, the Lilang limestones of the Spiti valley, and the dark limestone seen at the top of the Hangrang pass, as both resembling typical Krol rocks, I need perhaps hardly add that they also closely resemble each other. In the absence of fossil evidence to the contrary, I conclude that the upper Hangrang beds belong to the Lilang series.

I may mention in passing, that I saw the conglomerate again a few miles beyond Dankar, on the left bank of the Spiti, a few feet only above the bed of the stream. A considerable thickness of a light colored calcareous sandstone containing pebbles similar to those in the conglomerate opposite Mani is overlaid by a brown slaty rock, also containing similar pebbles. This conglomeratic sandstone is composed of grains of unequal size cemented together with carbonate of lime and earthy matter exhibiting rusty reddish spots on the fractured surface. It appears to have been squeezed up from below the strata at the point indicated, having been subjected to great strain and contortion.

The section from Dankar up the Spiti is described at pp. 26, 33 of Dr. Stoliczka's Memoir, and it appears from the remarks at p. 33 that between Losar and the Kunzam pass, the section is a repetition of that described by Dr. Stoliczka between Muth and Kuling. At the point where the road turns up the Lichu valley between Losar and the Kanzam pass, I observed a thick bed of pink limestone; but as a storm of two and half days' duration had covered the whole country with snow, and inflicted on me a sharp attack of snow-blindness, I was unable to explore this locality in detail.

The slates re-appeared near the Kanzam pass. From the top of the pass (elevation 14,931 feet, T. S.), down to Kátza, a halting place where the Chota Shigri river joins the Chandra, they resemble typical Simla slates. Dip north-east-by-north. On the left bank at Kátza the dip suddenly changes to very high south-south-west, and the slates are more silicious, and some of them have a micaceous glaze previously absent. The central gneiss appears with the Bara Shigri river, and huge blocks of it form a prominent feature in the moraine of the Shigri glacier. As I was making forced marches over heavy snow, I could not linger to explore this interesting neighbourhood, but Dr. Stoliczka states (p. 15 of Memoir) that "the boundary of the gneiss and of the *overlying*[1] silurian rocks" may be seen on a stream north of the Shigri glacier, six miles in a straight line south of the Kanzam pass. The Chota Shigri is probably the stream indicated.

[1] *See* also p. 17 and p. 341 of Vol. V.

The Shigri moraine passed, the talus of the mountains on the left bank of the Chandra consists of nothing but blocks of central gneiss, and finally that rock itself crops out *in situ* on the road side.

The absence of blocks of foreign rocks, I notice in passing, is hardly favourable to the view that the glaciers of the upper Chandra became confluent and flowed down the valley in recent geological times.

The central gneiss of the Chandra valley is often granitoid, and is penetrated by the albite granite (Memoirs, vol. V, p. 170). It extends to near the top of the Hampta pass (elevation 14,000 feet), where mica schists show under it, dipping north-west. Descending into the Kulu valley the gneiss shows for a considerable way, when it is succeeded by mica schists. The dip flat on the top of the pass, gradually veers round to west, and this again brings down the gneiss. The dip, which is usually low, wavers about sometimes in one direction and sometimes in another, being south-east at Jagatsukh and north-east at Dwára.

The continuance of the central gneiss in the micaceous and silicious schist beds, up to a mile north of Naggar, is attested by the presence of angular blocks on the road side that have tumbled down from cliffs above. From this point to Bajaura the metamorphic rocks consist principally of a dull brown mica schist, that smells earthy on the fractured surface, and generally does not show any indication of mica on its weathered surface.

The section between Sultanpur and Narkanda has been described by Mr. Medlicott (Memoirs, vol. III, p. 57), but I may briefly note, to complete this sketch, that the Sutlej valley limestones suddenly crop up about a mile south of Bajaura, and abruptly disappear about two and half miles north of Manglaur, where schists similar to those described as occurring between Naggar and Bajaura re-appear. The gneiss shows in force several times between Kot and Dulash, and frequently from thence down to the bed of the Sutlej. On the Kotgarh side, the dip coinciding with the slope, it is the only rock seen for 1,900 feet of vertical height above the river. From this point to within a few miles of Mattiána the rocks consist of schists similar to those south of Naggar in the Kulu valley.

The "graphitic schists" on the north side of the Jalori pass[1] are very similar to rocks seen round Kotgarh, and between the latter place and the Nogli river south of Rámpur. These rocks puzzle me very much. They are dark carbonaceous schists or slates with a micaceous glaze on them, and by their disintegration make coal-black earth. They are associated with limestone which occurs in more than one place on the north side of the Jalori pass, and a band of which crops up in several places under Kotgarh and along the Sutlej valley up to the Nogli river. Are these Infra-Krol rocks, lying closely on the crystalline series, or do they belong to the latter? The former would appear to me probable.

But without drawing any inference from these doubtful rocks, my observations during the present and previous tours show that, on the north as on the south of the central gneiss, the upper calcareous groups of the great palæozoic series originally overlapped the slaty series and rested on the crystallines.

[1] Mem. G. S. I., Vol. III, pt. 2, p. 57.

GLACIATION.

On the top of Chandan Námo pass (close to the Ga station, above Chango), I observed a considerable number of rounded river boulders of red quartzite and other rocks that do not occur locally. The red quartzite was probably derived from the Muth beds in Spiti. Beyond and at a lower level, I occasionally met with rounded boulders of trap, doubtless from the palæozoic formation of that valley (Memoirs, vol. V, p. 20), whilst 670 feet above the Para river, I observed numerous horizontal beds of *river* conglomerate. The boulders on the top of the Chandan Námo pass were undoubtedly rounded in the bed of a river by the action of the water, and there are no grounds for supposing that they were ice borne The only explanation that appears reasonable to me is that the bed of the Spiti river was formerly as high as the top of the Chandan Námo pass, which is about 2,400 feet[1] above the present bed of the Spiti river.

Dr. Croll, in chapter XX of his Climate and Time, and Professor Geikie in chapter XXV of Juke's and Geikie's Manual of Geology (3rd edition, 1872), discuss the rate of the erosion of rock surfaces evidenced by the amount of sediment annually carried down by the river systems; and the rate of erosion at which seven rivers specified remove one foot of rock from the general surface of their basins is said to vary from 6,346 years in the case of the Danube, and 6,000 years in the case of the Mississippi, to 929 years in the case of the Po. The rate given for the Ganges is one foot in 2,358 years.

Professor Geikie takes "the proportion between the extent of the plains and table lands of a country and the area of its valleys to be as nine to one," and assumes "that the erosion of the surface is nine times greater over the latter than over the former area." If, adopting this principle, we assume that within the mountain valleys of the Gangetic basin the erosion is nine times more rapid than over the rest of the basin, this would make the rate of erosion over the mountain area one foot in 262 years.

But the agents of denudation are much more powerful within the river basin of the Ganges than within that of the Sutlej. The watershed of the Ganges embraces a large area of exceptionally heavy rainfall, rising as high as 524 inches per annum in the Khasi hills, being "the greatest rainfall in the world," (Huxley's Physiography, p. 48); and within this area the agents of denudation must operate with exceptional activity. The rainfall over the watershed of the Sutlej, on the other hand, is comparatively light, being probably greatest at Simla, where the average for 15 years, from 1862-63 to 1876-77, was 75·1 inches. As you proceed higher up the Sutlej, the fall decreases, and beyond Wangtu becomes extremely light.

[1] Measured by my aneroid barometer, the elevation of the Spiti river at Leo is 9,550 feet, and at the confluence of the Ghu river 10,125 feet, the distance between the two points, measured straight across the map, being 13 miles. The top of the pass measured by my barometer is 12,340 feet. The weather being fine and cloudless, there could have been little variation from climatic causes.

Mr. J. B. Lyall, in his settlement report of the Kángra district (1874), states (page 164) that "light showers of rain occur" in Spiti, "in July and August; and in winter, snow falls only to the depth of 2½ feet." As "10 inches of snow roughly represents 1 inch of rain" (Huxley's Physiography, p. 63), 2½ feet of snow is equivalent to a rainfall of 3 inches. Even on the assumption that the fall of snow on the high peaks and passes is greater than that mentioned by Mr Lyall, the average for the whole of the Spiti valley cannot be in excess of 10 inches in the year, and the bulk of this falls as snow.

No hot winds penetrate to these elevated and mountain-locked regions to cause sudden thaws ; the clear frosty air is usually without a cloud, and the snow "melts gently" (Lyall, p. 162).

That denudation proceeds slowly in the region under consideration will, I think, be evident when we consider that though the Spiti (a tributary of the Sutlej) flows over comparatively soft limestones and friable slates, whilst the Sutlej at Wangtu has to cut its way for miles through intensely hard granitic gneiss, yet the bed of the Spiti opposite Shalkar is still 4,724 feet above the Sutlej at Wangtu,[1] the distance between the two points being only 45 miles as the crow flies.

The deepening of the bed of the Śatlej at Wangtu must be a very slow process, but clearly the excavation of the Spiti valley is a still slower operation

The fall of the Sutlej at Wangtu is about 50 feet per mile.

I think, with reference to the only data we have to enable us to form a rough idea on the subject, that the rate of the deepening of the bed of the Spiti at the point under consideration is probably not more rapid than 1 foot in 400 years At this rate it would require 960,000, or in round numbers say about one million of years,[2] for the excavation of the Spiti valley between Shalkar and the Ga station.

At the rate of 1 foot in 400 years, the total depth excavated in 80,000 years would be 200 feet only; so that if the last glacial epoch terminated as recently as 80,000 years ago, the date fixed by Dr. Croll on astronomical data (pp. 325-327, Climate and Time), the Upper Sutlej and Spiti rivers, and the agents of denudation operating on the slopes of their watersheds, cannot have effaced the broader marks of the work done by glaciers during that period. If then any *great* increase of glaciation during the last glacial epoch took place in the region under consideration, we ought to find decided traces of ice sculpture in our Himalayan upland slopes and valleys.

A similar conclusion appears to have been arrived at by experienced geologists regarding England. "Post-glacial denudation generally," states Mr. Good-

[1] The Sutlej at Wangtu, 116 miles beyond Simla, is 5,200 feet above the sea,

[2] This is less than half the rate adopted by Geikie for his average valley. "For we find by a simple piece of arithmetic, that at the rate of denudation which we have just postulated as probably a fair average, a valley 1,000 feet deep may be excavated in 1,200,000 years, a period which, in the eyes of most geologists, will seem short enough." Juke's and Geikie's Manual, p. 481.

child (Q. J. G. S., vol. XXXI, p. 99) "has affected so little, that by far the greater part of the present surface-configuration has in one way or another resulted from the former presence of the great ice sheet."

Bearing this principle in mind, I looked around me, during my recent tour, for the evidences of former glaciation. I do not know whether any one has ever supposed that the Himalayas were covered during the last glacial period with an ice cap, but I may note that whilst I saw nothing to favor such an idea, I saw much to negative it. The contour of the hills and valleys in those parts of the interior of the Himalayas that I have visited is sharp and angular, and where rounded outlines are seen, they are sufficiently explained by the action of sub-aërial forces on comparatively soft and friable rocks.

But setting aside the idea of an ice cap, the question remains—was there formerly any great extension of local glaciers, and if so, within what limits? To this question I answer that, whilst I saw evidence of the former extension of existing glaciers, I saw nothing during my tour to lead me to believe that these glaciers had ever, within a reasonable geological period, extended lower than 11,000 or 12,000 feet above the sea.

On looking down from a high vantage ground, deep narrow side valleys may be seen on the Upper Sutlej, below that level, in which the course of the streams flowing through them is so sinuous that the sharp headlands formed by their sudden bends interlace like the nuts of cogwheels working into each other. The flow of ice in a glacier being analogous to the flow of water in a river and its tributaries, a grand glacier filling the valley of the Sutlej would not have prevented the flow of ice from the side glaciers into the main glacial stream. But had these side valleys ever been filled with glaciers, the sharp interlacing headlands would have been gradually worn down to smooth surfaces, and the valleys straightened and widened.

The only valley in the Himalayas I have yet seen that is shaped like a glacier valley is the Spiti valley. The greater part of it is more than 11,000 feet above the sea, and its bottom, especially in the upper half of the valley, is broad and flat, whilst the bounding mountain sides rise abruptly in a wall-like manner at a high angle, and send no sharp projecting spurs into the valley. But if, as I think highly probable, the upper portion of the valley owes its shape, in part at least, to the action of ice, the period during which a glacier flowed down the straight course of the Spiti river must have been very remote; for I noticed about half the way up the valley a side valley partaking of the character of those described above; whilst the flat boulder bed which, in the upper valley, rises high above the river, seems to owe its origin in part to the action of the river, and in part to talus shot down from the bounding cliffs. It is not of glacial origin.

I now proceed to note the evidence which I obtained of the former extension of glaciers. At the head of the Spiti valley the Lichu river flows down from the peaks that surround the Kunzam pass, into the Spiti. There is probably a glacier up the side valley crowned by the snowy peak 20,581 feet high, but there is now no glacier in the Lichu valley between the Spiti and the Kunzam pass. About four miles in a straight line from the top of the Kunzam, a spur from the Shilatakar peak runs down to the Lichu river, and an ancient glacier in its course down the valley must have ridden over it. The rocks there, at an elevation of 14,000 feet, are thinly laminated slates, the dip of which is perpendicular, and the strike of which points across the valley at right angles to what must have been the course of the ancient glacier. The slates generally break up on the surface in thin flaky slices, but here and there long patches of the rock are *moutonnée*, polished and striated. The polishing is even now sufficiently perfect to obliterate all traces of the lamination of the slates. The striæ are well marked; they are generally in a direction of the axis of the valley, though they often cross each other at inconsiderable angles. As evidence of former ice-action nothing would be more complete and perfect. The splinting friable slate on which this ice-action is recorded is the last sort of rock on which I should have expected to find it.

Regarding the recession of glaciers, I note that the Big Shigri, as evidenced by its terminal moraine, has shrunk somewhat; but in the case of the Pirad glacier, the next to the west of the Bara Shigri, the shrinking is very evident. The road passes within about quarter of a mile of this glacier, and from either side of it a large lateral moraine may be seen curving down the valley until it reaches the river, three-quarters of a mile, or a mile, from the present end of the glacier.

Again, the head of the valley, up which the road to the Hamta pass lies, is filled by a glacier that extends a little below the entrance to the pass. The old terminal moraine of this glacier may now be seen about one and a half miles lower down the valley, rising in steep banks some 50 or 60 feet above the talus, shot down from the sides of the valley.

About a quarter of a mile below the Pirad glacier, on the side of one of the moraines, there is a huge block of the central gneiss, well rounded, polished and striated on all sides but one.[1] The impression I derived from examining it was that it must have originally been a boss of rock projecting from the side or bottom of the glacier bed, and that it was ultimately torn away from its parent rock and deposited where it now rests. I did not measure the block, but it cannot be smaller than 50′ × 50′ × 50′. One side has been ruptured from the block, apparently by the action of frost on water filling a crack, and its pieces rest by its side.

[1] Exclusive of the side on which it rests, which, of course, cannot be seen.

NOTE ON A RECENT MUD ERUPTION IN RÁMRI ISLAND (ARAKÁN) BY F. R. MALLET, F.G.S., *Geological Survey of India.*

In the account of the mud volcanoes of Rámri and Cheduba given in Volume XI, part 2, it is mentioned that there is a notion prevalent amongst the islanders that eruptions take place more frequently during the rains than at other times of the year. The few dates of eruption on record, in as far as they go, do not bear out this idea, but the number is too small to generalise upon.

Were the idea of an increase in activity during certain months of the year confined to the unsophisticated inhabitants of these islands, the point might perhaps be scarcely worth examination. A greater tendency to eruption at certain periods has, however, been suspected to exist in some other parts of the world. It is stated by Dr. Horsfield, that eruptions from the mud volcanoes of Java are more violent during the rainy season than at other times, and M. Dubois de Montpéreux mentions that out of six eruptions from the mud volcanoes near the entrance to the Sea of Azov, five occurred between February and the 10th of May, the only known autumnal eruption having been on the 5th September.[1] Whether, therefore, the belief of the Arakán islanders be well founded or not, the point is worth investigation.

In this connection the following letters, which have been placed at the disposal of the Geological Survey by the Commissioner of Arakán, are valuable as the first contribution towards a catalogue of eruptions sufficiently extended for generalisation. It is hoped that we may be able to make such in time through similar communications from the Officials of the Rámri district, and others who may take an interest in the subject.[2]

From CAPTAIN J. BUTLER, Deputy Commissioner, Kyouk Phyoo, to the Commissioner of Arakán, Akyáb,—No. 35-12, dated the 16th July 1878.

In compliance with the instructions conveyed in your letter No. 732-165, General Department, dated 22nd ultimo, I have the honor to state that the following individuals were

[1] Records, G. S. I., Vol. XI, p. 201.

[2] It will be seen by reference to the paper quoted above, that there are some other points, also, connected with the eruptions, concerning which our information is not sufficiently detailed. The following list of questions may perhaps be useful as a guide in obtaining information from the villagers :—

1. Informant's name and village.

2. Locality at which the eruption took place. Name of village, with distance and bearings from one or two well-known places.

3. Date of eruption, and time of day at which it commenced.

4. Was it preceded or accompanied by any perceptible earthquake?

5. How long did the eruption last? Did it begin suddenly, or increase gradually in violence, and did it end suddenly or gradually?

6. Were there any flames during the eruption? If so, how high did they rise above the top of the hill, when largest, and how long did they last? Was the flame continuous or intermittent?

7. What is the shape of the hill, and its height? Was it formed entirely during the recent eruption, or was part of it there previously? Is it conical, and is there a basin or hollow (crater) at the top? If so, what is the diameter of the hollow, and does it contain mud?

examined by the Kin Thoogyee, relative to the volcanic eruption which took place in his circle a few months ago, *viz.* :—

1. Kulla-kyee of Kon-boung Tau Village,
2. Ya-ba Hkyoung of Peu-lay-na ditto,
3. Pau Hla Oo of ditto ditto,
4. Tha Htoon Hpyoo ditto ditto,
5. Tha Htoon Oung ditto ditto,
6. Ya-ba Oung of Loung-Hkyooein ditto,

and from their collective evidence the Thoogyee has communicated the following :—

1. The eruption occurred near the village of Peu-lay-na, a spot bearing about 460 yards north of the above village, 1,000 yards west of the Yua Ma village, and ½ of a mile east of the sea-shore.

2. It occurred on the 19th of March 1878, at 7 o'clock in the morning.

3. No earthquake occurred, the earth merely cracked, and from the fissure a hill began gradually to rise.

4. The eruption lasted 11 days, and began increasing gradually day after day, ending in the same manner. This was ascertained by means of a post which was put into the earth for the purpose of watching the height of the hillock as it increased. A few days, however, before the eruption ceased, the post was found lying some 14 or 15 cubits distant from the place where it had been put in.

5. No flames occurred at the time of the eruption: a lad, however, who happened to be close to the spot, accidentally dropped into the crater a box of matches, when immediately a large flame to the height of about 25 cubits above the top of the hill issued forth, and which continued burning for two days and a night before it went out.

6. The shape of the hill is said to resemble an inverted boat, and its height is 18 cubits. There was previously in the same spot a small hill about 9 feet high, and on this hill the eruption took place. The hill is flat on the top, cracked in several places, and the cracks filled with mud.

7. The lava or stuff[1] thrown up was mud mixed with stones, and the mud thin and watery; when first thrown out the mud was warm. Inside the cracks it is very hot when felt by the hand. The stones were small in size, and were not thrown up much higher than the summit of the hill.

8. There is another hill of the same kind as this one in the neighbourhood which was formed over a hundred years ago.

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8. Was the stuff thrown up mud only, or mud mixed with stones? Was the mud thin and watery, or thick? Was it cold, warm, hot or very hot when first thrown out? How large were the biggest stones thrown out, and how high were they thrown?

9. Are there any other hills of the same kind in the neighbourhood, and if so, have any of them been formed during the remembrance of the present generation; if so, how many and when?

Any further information will also be acceptable.

[1] Specimens sent to the Geological Museum were light grey mud and pieces of grey shale. A few pieces were reddish, doubtless from having been exposed to the heat of the flames.—*Vide* Vol. XI, pp. 196, 201. 202.

9. The Burmese, as a rule, are very superstitious in matters of this sort, and generally ascribe such a phenomena to the work of a dragon (Nagah).

From CAPTAIN GEORGE ALEXANDER, Officiating Deputy Commissioner, Kyouk Phyoo, to the Commissioner of Arakán Division, Akyáb,—No. 3, dated Camp Rámri, 11th December 1878.

I have the honor to submit a further report on the subject of the volcanic eruption near Moo-yin in the island of Rámri, and in continuation of my letter No. 35-12 of 1878.

The mound first made its appearance on the night of the 18th March 1878; at least the first people who saw it were some women, who went out to cut wood before dawn on the morning of the 19th, and came across a mound gradually rising from the earth, and being frightened, believing that it was a "Nagah Doung", or hill raised by a dragon, they ran away. They saw no fire, nor did they perceive any earthquake. They state that the mound continued rising for 12 days, and that it was on fire for a day and a night. Lah Bah Chyoung, the writer of the circle Thoogyee, who visited the spot at about noon on the day in question, says he found smoke and fire issuing from cracks in the mound when he arrived, but states that the surface of the ground was smooth and hard; that the earth was being forced out of an area of about three bamboos or 36 feet in length, and gradually made its way westward towards the sea. It appears to be doubtful whether the mound itself vomited fire, or whether it was set on fire by a small child with a cheroot; at any rate it was on fire on the day after its appearance, and the flame burnt for two days, not steadily and regularly, but spurting up into the air by fits and starts, for some 20 or 30 cubits; there was a strong smell of earth-oil whilst the mound was on fire, and it is described as having been so powerful and pungent as to make the women near giddy; there appears to have been no active sudden eruption, merely an upheaving of the earth gradually. And the villagers state that sticks planted 6 inches or a foot in the ground in the evening would be found to have been carried considerably westward by morning, the first night 14 cubits; but the distance kept decreasing inversely as the days went by. This information is gathered from the women who first saw the mound and from other residents close by.

Directly inland, and at a distance of some 300 or 400 yards from the present upheaval, is a conical hill which has the appearance of being one of volcanic origin. The present elders of the village state that in the year 1146 (Burmese era), or 94 years ago, a volcano appeared which threw out large quantities of stones and residue, and gradually formed a hill which some 65 years ago was about 23 feet high, and which is now estimated at about 40 feet high, although it is difficult to say where the hill begins, and the top is considerably more than this height above the surrounding paddy cultivation. This mound is called by the Arakanese "Nagah Bwai" or dragon's circle, and has been in active eruption some four or five times during the life of one of the present elders, at a few hours at a time, and the stones thrown out on each occasion have caused the hill to increase in bulk. Whenever the eruptions took place at the Nagah Bwai hill, the same strong smell of earth-oil was perceivable; the last eruption took place about five years ago. Some of the stones found at the spot where the last upheaval of the earth occurred have been collected by myself personally, and as the Officers of the Geological Department expressed a wish to have some of these stones, I forward the same, as they may cast some light on the causes that influenced this phenomenon of nature.

There seems to be little reason to doubt that earth-oil in one form or another was the disturbing influence.

ON BRAUNITE, WITH RHODONITE, FROM NEAR NÁGPUR, CENTRAL PROVINCES, *by*

F. R. MALLET, F.G.S., *Geological Survey of India.*

Some time ago, Mr. W. Ness, Mining Engineer in charge of the Warora Collieries, sent a parcel of about 20 lbs. of manganese ore to the Geological Museum, with a notice of the locality in which it had been found. It appears from this that the ore occurs on the south-east side of Munsur Great Trigonometrical Station, a hill three miles west of the town of Rámtek, which is about twenty miles north-east of Nágpur. Mr. Wilson, Executive Engineer of the Kanhán Division, who has visited the place, describes the outcrop, which strikes north-west, south-east, as being visible for about a quarter of a mile, with a thickness of about 10 feet. Mr. Ness, however, is inclined to think that some portions are inferior to the samples sent to the Museum.

The latter are finely-granular massive, with here and there portions which are indistinctly crystalline on a larger scale. The specimens are bounded on two opposite sides by planes which appear to be joint-faces, approximately perpendicular to which the mineral is intersected by irregular, more or less elongated cavities: the larger of these are about an eighth of an inch across, and some as much as three or four inches long: others are visible only under the lens. Many of them are partially, or almost entirely, filled by a translucent, light brownish-red and yellowish, indistinctly crystalline mineral, which proved on examination to be rhodonite.

The color and streak of the manganese ore are brownish-black. Hardness about 6·0. The specific gravities of three different samples were 4·22, 4·36, and 4·46, the differences (and the inferiority in gravity to that of braunite in crystals) being doubtless partly due to minute cavities.

On analysis the mineral yielded, counting all the manganese as sesquioxide, according to the formula more usually adopted for braunite—

Manganese sesquioxide	78·64	79·39
Iron sesquioxide	9·78	9·87
Lime	1·20	1·21
Magnesia	tr.	tr.
Oxygen in excess of that required for M^2O^3 ...	1·65	1·67
Silica	6·00	6·06
Phosphoric acid	·21	·21
Combined water	2·61	2·63
Hygroscopic water	·60	...
Disseminated rhodonite	·35	...
	101·04	101·04

The second column gives the composition exclusive of hygroscopic moisture and rhodonite, scattered minute grains of which can generally be detected by the lens even in the most homogeneous specimens. Being but little acted on by hydrochloric acid, it is left undissolved, together with gelatinous silica. The excess of oxygen, and the presence of water, show that the braunite is not in a pure state, having probably undergone partial alteration.

The ore contains 55·27 per cent. of manganese and 6·91 of iron. The main use of manganese ores, however, is as oxidizing agents, their value depending on the amount of available oxygen they contain. Pyrolusite, or peroxide of manganese, the richest in oxygen and most valuable ore, contains when pure 18·39 per cent.; and ores are generally valuated by the percentage of peroxide they contain, or more correctly speaking, the percentage of peroxide, to which the oxides they contain are equivalent in available oxygen. The average run of ores met with in commerce contain 60 to 75 per cent. of peroxide = about 11 to 14 per cent. of available oxygen. The Nágpur braunite contains 9·71 of available oxygen = 52·80 per cent of peroxide. As an oxidizing agent, therefore, it cannot be classed as more than fairly good.

A deposit of the same class of manganese ore was found by Mr W. T. Blanford in 1872, at the village of Kodaigowhan (near Khappa), 20 miles due west of Munsur, Great Trigonometrical Survey.

PALÆONTOLOGICAL NOTES FROM THE SATPURA COAL-BASIN, *by* OTTOKAR FEISTMANTEL, M.D., *Palæontologist, Geological Survey of India.*

In the beginning of last year (1878) I had an opportunity of traversing from east to west a portion of the great Sátpura coal-basin, with the special intention of collecting fossils at certain places. Taking as guide the last report on this ground[1] I started from the Gádarwára station, Great Indian Peninsula Railway, for the Mohpáni coal-field, of which a brief description was published[2] in 1870.

Mohpáni field.

With assistance of the manager of the Mohpáni coal mines, Mr. Maughan, I was enabled to collect what fossils were to be got, which to some extent permitted of a comparison of the Mohpáni coal seams (in part at least) with some other known horizon of the Indian coal strata, as given in my recently published flora of the Talchir sub-division.[3] I shall repeat only what is necessary for general understanding in the present paper.

In the report referred to, the close relation of the Talchirs and the coal beds in the Mohpáni coal-field is pointed out; and this view seems to be supported by the fossils, which bring these coal seams on the horizon of the Karharbári coal beds, which latter were recently shown to belong to the Talchir division.

The fossils which I collected were found in a band of shale in the uppermost of the Mohpáni coal seams, which are outcropping in the valley of the Sitariva river, on the right bank of which the only mines of importance at present are situated.

Fossil plants.

1 H. B. Medlicott: Mem. Geol. Surv. of India, Vol. X.
2 H. B. Medlicott: Rec. Geol. Surv. of India, Vol. III.
3 Pal. Indica, Ser. XII, 1.

The fossils are few in species, although numerous in specimens, and I could observe—

Equisetaceous stalks, some of which, I think, are of *Schizoneura*; *Gangamopteris*, pretty frequent, both in the original form *G. cyclopteroides*, and as a variety, *i. e.*, *G. cyclopteroides*, var. *attenuata*. *Glossopteris* almost equally numerous as *Gangamopteris*.

This distribution of the fossils appeared to me to be similar to that in the 3rd seam of the Kaharbári coal-field, and as I endeavour to show in the paper referred to that this seam also is to be considered as belonging to the Karharbári beds, there would be no objection to the Mohpáni seams being considered also as on the horizon of the Karharbári beds.

Parasuchian crocodile at Jhirpa.

From Mohpáni I moved towards Pachmari, over ground formed of Mr. Medlicott's Bágra and Denwa groups. Close to Jhirpa, on the right bank of the Denwa, a specimen of a large scute of a *Parasuchian* crocodile was picked up by Mr. Hughes two years ago, and it was therefore my object to examine the place, if more remains could be found. I followed the river for some distance in north-western and western direction, but not a fragment could be discovered; so I crossed the Denwa and moved on to Singanáma, on the road from Bankheri to Pachmari, quite close to the boundary between the Denwa group of rocks and the next lower group, the Pachmari sandstone.[1] To the east of Singanáma, about 1½ mile, in the gorge of the Denwa, the rocks are fully exposed, and a little to the south of the village Moár, on the right bank of the river, the junction of the Pachmari and Denwa groups is well seen, when it is clearly observed that the Pachmari sandstone dips without any unconformity beneath the Denwa group with the same northerly dip. From Moár I went all along the Denwa valley to the north, back to Jhirpa, in search of fossils in the Denwa group, but also this time nothing was found. There is only one more locality where some organic remains were found in the Denwa group, *i. e.*, far to the west near Kesla on the road from Shápur to Itársi, where Mr. Medlicott procured some plant remains in a very crumbling mottled shale, which, after close examination, proved to belong to *Glossopteris*. This is all our palæontological knowledge of the Denwa group up to date.

Section at Moár.

Plant remains in the Denwa group.

Pachmari sandstone.

Proceeding from Singanáma to the south-west towards Pachmari, the ground rises rapidly up to the Pachmari plateau, which has an elevation of 3,481′, the surrounding hills, specially to the south and south-west, being much higher, rising to 4,384′ in the Mahádeo hill,

[1] I may perhaps mention, that before crossing the Denwa river near Jhirpa, I was encamped at Mauljhar on the road from Chindwára to Bankheri, to the south-east of which near Anoni-Dhána, there is a hot spring with exhalations of inflammable gas; it is at the head of a small nalla which receives its water from this spring, which is pretty strong, and the gas escapes at about ten places; at the source the water had a temperature of 130°F.; below this it is collected in a sort of a small tank, where it shewed 102°F., and from here it passes into the nalla. It is, of course, in high estimation with the natives, and close to it is a primitive temple of Mahádeo with a Jogi in attendance.

to 4,317′ in the Chóradeo, and to 4,454′ in the Dhupgarh. Close to Singanáma we pass from the Denwa group on to the Pachmari sandstone, of which the whole Pachmari plateau as well as the mentioned hills consist. This Pachmari sand stone proved, in spite of careful examination, unfossiliferous.

Proceeding from Pachmari southwards, the road, always over Pachmari sandstone, leads close by the Mahádeo hill, passing the famous Mahádeo cave in the northern flank of the hill; from this cave the descent into the upper valley of the Denwa is very rapid, down the steep and abrupt slopes of the southern side of the plateau. About 1½ mile before reaching the Denwa the slope becomes more gentle, and before reaching the police station at foot of the Pachmari range (which is about ¾ of a mile from the Denwa) there is a change of rocks, *i. e.*, under the Pachmari sandstone there appear soft, sandy, micaceous shales of greenish, yellowish, or brownish-yellowish colour, which apparently have the same northerly dip as the overlying Pachmari sandstone; that this is the case I have found further on. Here these shales proved unfossiliferous. Similar shales occur further to the north-west near Almod and Rorighát, where they were found to contain only some indistinct plant impressions.

Shales under Pachmari sandstone.

In his report on the Sátpura basin, Mr. Medlicott, speaking of his Bijori horizon, mentions two possibly different bands, of which the higher might be distinguished as Almod beds; and it appears to me that the shales which I just mentioned as cropping out under the Pachmari sandstone might possibly represent these Almod beds; because, when proceeding further to the south close to the Denwa river, the shales change somewhat in appearance, they become a little harder, greyish and grey colours appear, and they are fossiliferous. In position they are lower than the shales mentioned before, both having the same dip. To have a better opportunity and more time to collect fossils I crossed the Denwa river near Sangakhera Dhána and encamped at Barikondam, where I was also close to the spot where the reptile said to be *Archegosaurus* was found in this lower horizon.

Bijori horizon.

The place where I collected fossils in the shales lies directly to the north of Barikondam, on the left bank of the Denwa river, between this and the police station at the foot of the Pachmari range. The shale crops out at the base of a small hill, on the eastern slope of which the road from Pachmari leads to the Denwa river, cutting through shales containing fossils. A little to the east of this hill, but still before crossing the Denwa river (coming from Pachmari), in a small nalla which the road has to cross, an instructive section is exposed showing the relation of the strata south of the Pachmari range to the Pachmari sandstone, as follows, in ascending order:—

Fossil plants in the Bijori horizon.

a. Dark-grey carbonaceous micaceous shales dipping north at about 15°, containing *Vertebraria*.

b. Greenish-reddish shales slightly micaceous.

c. Coarse thin-bedded sandstones, with the same northerly dip.

Above these sandstones is a series of sandy micaceous shales, which in this place contain no fossils, but which I believe to be the same as those at the base of the hill mentioned as on the left bank of the Denwa (north of Barikondam) where I obtained fossils; above these sandy shales is a bed of fine earthy bluish-grey or reddish-grey shales with plant fossils. Above these there would come in the sandy micaceous shales which I mentioned before as immediately below the Pachmari sandstone, and then these sandstones themselves, all apparently with the same dip. I obtained the following fossils from these localities :—

a. From the base of a small hill on the left bank of the Denwa river north of Barikondam in brownish-yellow, greenish-yellow, sandy and earthy micaceous shales which do not split regularly; the fossils are plants only and very fragmentary—

Glossopteris communis, Fstm.

Glossopteris with horizontal broad meshes (called in manuscript *Gl. damudica*).

Glossopteris, another form with distinct polygonal meshes, which form occurs also in the Ráníganj group of Bengal, and which will be described as *Gl. retifera*.

Pecopteris comp. *angusta*, H. (*Merianopteris angusta*, H.). This species occurs in the Trias of Europe. A form of the same genus is known also from the Ráníganj group.

Diksonia (comp. *Concinna*), a form which appears to me to be the same as that found by Mr. Hughes in the Ráníganj group of the Jheria coal field, and figured by me in 1877.[1]

b. To the east of the place just mentioned fossils were found, as already stated, in fine earthy light grey, bluish-grey or reddish-grey shales which appear to me to be above these shales. The fossils were—

Equisetaceous stalks, of which some may belong to *Schizoneura*, as this genus was found in this horizon.

Vertebraria indica, Royle; small specimens.

Glossopteris predominant; different forms.

Glossopteris communis.

Glossopteris indica, Schimp. (one specimen with little oblong marks as if indicating the Sori).

Glossopteris with broad horizontal meshes (*Gl. damudica*).

Glossopteris leptoneura, Bunb.; narrow leaflets.

Gangamopteris, a form with small roundly ovate leaves.

A round winged seed of the genus *Samaropsis*, Göpp.,[2] much resembling Heer's *Samarops rotundata*.[3]

Some other small seeds, not winged, resembling very much seeds of the same kind from Damuda rocks in South Rewa, collected by Mr. J. G. Medlicott.

Other fossil plants in the Survey collections.

Besides these fossils collected by myself, there were some other specimens from the same district in our collections. One lot of about fifteen specimens was labelled, "Upper Denwa valley near Barikondam;" the fossils are plant impressions in an earthy-reddish

[1] Rec. Geol. Surv. of India, Vol. X.

[2] *Fructus samaroideus, membranaceus compressus, margine alatus, monospermus.*

[3] Heer: Flora fossilis arctica, Vol. IV; Jura flora Ostsibiriens, etc., p. 80.

shale, and there is little doubt that they come from a similar bed of shales to that mentioned before as above the sandy micaceous greenish-yellowish shales with fossils. They comprise—

Schizoneura gondwanensis, Fstm The same form as in the Ránigauj, Jherria, and Hingir coal-field.

Glossopteris communis, Fstm. The same form as in other places.

Besides these there is a single specimen labelled "Denwa naddi, Pachmari." It contains—

Trizygia speciosa, Royle (*Sphenophyllum trizygia*, Ung), which chiefly occurs in the Ráníganj coal-field (Ráníganj group), in the Talchir coal field (Baiákar group), and is doubtfully quoted from the Damuda rocks at Pankabári.

There is no doubt that this specimen also comes from this fossiliferous zone of shales in the Bijori horizon in the Upper Denwa valley.

The Bijori horizon represents the Kámthi-Ráníganj group.

If we now consider the fossils mentioned above as coming from the Bijori horizon in the Denwa valley, *i e*, *Schizoneura gondwanensis*, Fstm, *Trizygia speciosa*, Royle, *Vertebraria indica*, Royle, *Glossopteris* in various forms, *Pecopteris angusta*, H, etc, we find that all these occur also in the Ráníganj group in Bengal, so that the fossiliferous band is correctly considered as representative of this group in the Sátpura coal basin, in which case those sandy micaceous unfossiliferous shales immediately below the Pachmari sandstone, and the beds of the same position near Almod and Rorighát (which have been distinguished as Almod beds), would perhaps represent the Panchet group of Bengal, this the more if we consider the close relation of this group in Bengal with the Ráníganj group, and the much smaller number of fossils in the former than in the latter.

Archegosaurus in the Bijori horizon.

I made also a search from Barikondam to the west, at and round the spot where the said *Archegosaurus* was picked up by Major Gowan;[1] but no trace of any fossil was found in the Bijori sandstone.

Shales at Almod and Rorighát.

Fine earthy sandy-micaceous greenish-yellowish shales were observed, as already mentioned, near Almod and Rorighát; except indistinct marks, they were found otherwise unfossiliferous, and they appear to be the same as those mentioned before as immediately underlying the Pachmari sandstone.

Plants between Rorighát and Harapála.

Further to the west, however, on the road from Rorighát to Shápur (by Harapála, Jhuli, &c.), about five miles from this place, I found in a nalla some shales containing plant remains.

[1] Journ. As. Soc., Beng., XXXIII, 1864, pp. 336, 442.

They are dark greenish-grey, rather hard, slightly micaceous. The fossils were not many, but sufficient to indicate the horizon. I collected—

Schizoneura gondwanensis, Fstm. One leaf.

Vertebraria indica, Royle. The more branched thinner form, like that in the Kámthi beds of the Ráníganj group.

Glossopteris leptoneura, Bunb.

Glossopteris, another species.

The fossils of this locality agree therefore with those mentioned before from the Denwa valley, and can be like these considered as on the horizon of the Ráníganj group.

Shápur coal-field.

The next observations were of the Damuda rocks and outcropping coal seams in the neighbourhood of Shápur. A full report on this field was published by Mr Medlicott in 1875;[1] my object was directed to the examination of the outcrops for their fossils.

In this coal-field also, like in that of Mohpáni, Mr. Medlicott points to the close relation of the coal beds (Barákar group) to the underlying Talchirs (*l. c*, p. 76), and this conclusion from stratigraphical grounds is perhaps also supported, partly at least, by the few organic remains. These are again plants only, and I think they partly show the existence of representatives of the Karharbári beds, indicating the close connection of these coal beds with the Talchirs.

Mardánpur outcrops.

I first visited the outcrops in the Machna river, north-east of Shápur. The coal crops out at two places; in both some fossils were found which tend to indicate two horizons. The more north-eastern outcrop is close to the village Mardánpur, in the river bed; there are two outcrops running parallel, one on the right and the other on the left bank of the river, but only that on the right bank appears of any importance, and when I was at this place a very primitive kind of mining (digging) was going on on this outcrop.

The dip is 30°, to north-west-by-north. This lower outcrop only was accessible for examination. The whole outcrop (shales included) measures 4 to 5 feet, dipping under white, open and rather coarse-grained sandstones. The coal itself is at this place not thicker than about 2′, being overlaid by coaly shales and underlaid by grey sandy shales, and in the coal itself there is a good deal of what is called fibrous anthracite.

Fossils.

The fossils at this place were very scarce: I found in the coal impressions of *Vertebraria*, and also in the underlying shales some impressions were observed which appeared to me to belong to the same genus.

Kotmi outcrops.

From these outcrops to the south-west up the river, we find other outcrops at the bend of the river west-south-west of Kotmi. The outcrop here passes from east to west across the river,

[1] Rec. Geol. Surv. of India, Vol. VIII.

and is better exposed on the left bank. The strata dip north-east-by-north, at about 15°. The sequence of strata on the left bank is the following (in descending order) :—

a. Uppermost sandstones.

b. Yellowish-brownish-grey sandy shales.

c. Grey earthy-sandy shales with *plants.*

d. A band of very fine earthy carbonaceous brownish-black shales with *plants* They contain also much pyrites.

e. The coal seam about 2 to 3 feet thick.

f. Shales and sandstones partly already in the river.

On the right bank there appears under these sandstones another bed of carbonaceous shales without coal. Fossils occur in the upper part of both these outcrops.

On the right bank I found in the grey sandy shales—

Glossopteris, fragmentary, and
Noggerathiopsis (Hislopi ?), fragments.

On the left bank were found—

a. In the black shale immediately above the seam—

Glossopteris, fragments.
Gangamopteris and *Nöggerathiopsis.*

b. In the sandy grey shales above—

Equisetaceous stalk.
Glossopteris communis.
Gangamopteris cyclopteroides, Fstm, several specimens.
Nöggerathiopsis hislopi.
Some small seeds (*Carpolithes*).

Here, therefore, were found more fossils than in the Mardánpur outcrops, and they perhaps indicate the horizon of the Karharbári beds.

Temni outcrops.

From here I went to see the outcrops in the Táwa river near Temni (on the map, but by the people called Temru); no fossils were found in the shales, which appeared to me to have a resemblance to Talchir shales; they perhaps represent, as Mr. Medlicott (*l. c.,* p. 80) suggests, the outcrops at Kotmi.

Outcrops in the Suki.

In the outcrops north of Shápur in the Suki river before it falls into the Táwa river, only very few and fragmentary fossils were found. In the lower beds of carbonaceous shales, I found fragments of Equisetaceous stalks and of *Nöggerathiopsis,* and in the upper one a fragment of *Nöggerathiopsis.* The beds dip to north-east-by-north at 10°.

There is no direct indication for a comparison of these outcrops with any of the others, the fossils being so very scarce, except perhaps from the position with the outcrops in the Bhoura naddi (near Sonáda).

About nine miles south-east of Shápur there are other outcrops in the Táwa river near the village of Dolári. Going from Dolári to the river and passing down it to the east, we meet the first (or lowest) seam No. I; it is underlaid by sandstones, and the following rocks are seen—

Dolári outcrops.

a. Brittle, sandy, greenish grey micaceous shales.
b. The coal seam about 2′ thick at this place, the coal, however, brittle and full of the fibrous anthracite.
c. Thin-bedded shaly sandstones.
d. Thin sandstones again up to the next seam.

No fossils were found in this outcrop.

We pass then from here eastwards over sandstones which become thin-bedded and shaly, until carbonaceous shales of 4′—5′ appear, without coal; above these shales some sandstones, and then again dark-grey shales are seen, under which lies the seam No. II, which, however, was then covered; but I saw at Dolári some old heaps of coal, which was said to have been dug from this seam. In the outcropping grey shales some fossils were found, although very fragmentary—

Equisetaceous stalks.
Gangamopteris cyclopteroides, Fstm
Glossopteris.
Nöggerathiopsis hislopi, Bunb., sp.

These fossils, although very scarce, yet perhaps permit of a comparison of this outcrop with that near Kotmi, and consequently also with the Karharbári beds. Here at Dolári, however, all the outcrops are so close to each other that they may well be considered as representing all the same horizon.

The IIIrd outcrop (to the east) was almost entirely covered by river sand. I procured only with great trouble a piece of coal which was of very inferior quality; but the thickness of the seam could not be ascertained.

The highest and last outcrop, the IVth, to the east, is exposed to some extent. On the underlying sandstones appear thin-bedded carbonaceous micaceous shales. with fragmentary fossils, then the coal seam about 2′ thick (at this place); then shales and sandstones. The only fossils I could observe were fragments of a *Glossopteris*.

As the last to be mentioned are the outcrops about eight miles to the north-west of Shápur in the Bhoura naddi (also Suk-Táwa), close to the village Sonáda. There are several outcrops three quite close to each other in the northerly bend of the river at the village, but they are much concealed, and no fossils could be procured. It would, however, not appear improbable that some of these outcrops at Sonáda represent those in the Suki river north-east of Tekripura.

Outcrops in the Bhoura naddi near Sonáda.

On my return way from Shápur to Itársi (Great Indian Peninsula Railway) I made a search round Kesla in the Donwa group. I think I found the decomposed mottled shales from which *Glossopteris* had been procured; but to my regret failed to find any fossils.

I may now mention that all these sedimentary rocks of the Sátpura coal-basin (south of the Narbada) constitute an unbroken series of beds of the Gondwána system from the Talchirs (the lowest) to the Jabalpur group (the highest), all being generally conformable, or very nearly so. The Jabalpur group, the Bágra-Denwa group, and the Pachmari sandstone form the upper portion of the Gondwána system, while the beds from the shales immediately under the Pachmari sandstones down to the Talchirs constitute the Lower Gondwánas.

The Lower Gondwánas in the Sátpura basin can therefore perhaps be classified thus—

a The shaly beds immediately below the Pachmari sandstone south of the Mahádeo hill near Almod and Ronghát; soft, earthy and sandy micaceous shales, greenish-yellowish, with indistinct plant remains. They may, as proposed by Mr. Medlicott, well be distinguished as Almod beds.	Probable representatives of the Panchet group.	Panchet sub-division.
b. Mr. Medlicott's Bijori horizon. Sandstones with shales, some of them carbonaceous and fossiliferous.	Represent the Kámthi-Ráníganj group.	Damuda sub-division.
c. Mr. Medlicott's Motúr horizon	Ironstone shales? ..	Ditto.
d. Barákars: some of the coal-beds in the Shápur coal-field.	Barákars .. .	Ditto.
e. Karharbári beds in the Mohpáni coal field and some of the seams (near Kotmi and Doláni) in the Shápur coal-field.	Karharbári beds ..	Talchir sub-division.
f. Talchir group in the Mohpáni and Shápur coal-field.	Talchir group elsewhere	Ditto.

I may add at end the relations of the several horizons as regards their fossils—

a. Jabalpur group: fossiliferous, plants only, of middle jurassic type (but also *Glossopteris* from the Sher river).

b. Bágra group (H. B. Medlicott) · no fossils known at present.

c. Denwa group: a scute of a *Parasuchian* crocodile from near Jhirpa (on the Denwa river) and some plant fragments (*Glossopteris*) from near Kesla.

d. Pachmari sandstone: no fossils known at present.

e. The shales immediately below the Pachmari sandstone: indistinct plant impressions (Almod beds).

f. Bijori horizon: shales with stalk remains: *Equisetaceous* stalks, *Schizoneura*, *Glossopteris*, *Pecopteris*, *&c.*

In the sandstones was found a portion of the skeleton of a reptile said to be *Archegosaurus*.

g. Motúr horizon: no fossils known up to date.

h. Barákars: some plant remains in the Shápur area (*Glossopteris* and *Nöggerathiopsis*).

i. Karharbári beds: in the Mohpáni coal-field and in the Shápur area: *Equisetaceous* stalks, *Gangamopteris, Glossopteris, Noggerathiopsis.*

k. Talchir beds: no fossils found in this district

STATISTICS OF COAL IMPORTATIONS INTO INDIA, *by* THEO W H. HUGHES, *Geological Survey of India.*

In the leisure of my leave on furlough I have attempted to gather some particulars on the Indian imports of coal and coke, which will, I think, be of interest and perhaps of some little value to those readers of our Records who are concerned about the mineral statistics of India. I had myself so often experienced the want of some readily accessible reference, which should contain in a connected form information on this subject, that I was emboldened to undertake the task of arranging such data as I could bring together, by the knowledge that I should be relieving others of that want. For a large portion of the details here given, more especially those relating to the earlier years, I am indebted to various abstracts and reports published by the Board of Trade and placed at my disposal by Mr. Robert Hunt of the Mining Record Office; for the rest, I have to acknowledge my obligation to Mr. Charles Prinsep of the Statistical Department, India Office.[1]

The annual consumption of fuel for sea-going and river steamers, for railways, for factories, and for other purposes has within the last year or two grown to something between 900,000 and a million tons, and of this amount it may be roughly said that one-half is foreign coal. However much this circumstance is to be regretted by those who are interested in the development of our own fields of supply, there appears to me to be small chance of a diminution in the ordinary rate of importation until native coal is lightened to some extent of the heavy burden of charges imposed by land carriage and by freights, so that it may compete on more favorable terms than at present with its rivals at the western ports of the Bombay Presidency, and those of Madras and Burmah. Our three principal coal mining districts, Rániganj, Karharbári, and the Wardha valley, are so situated that the item of railway transport alone—even in the case of the two more favourably situated fields, the Rániganj and the Karharbári—trebles and quadruples the actual costs of the coal by the time it reaches a port for shipment; and it utterly prohibits the sale of the produce of the Warora colliery (Wardha valley) within a distance of 200 miles of Bombay.

Beginning with the year 1853, the shipments of coal and coke to India were 43,562 tons. Since then, after the lapse of a quarter of a century, they have risen to 609,735 tons. The ratio of increase has not been by any means steady: wars,

[1] Without Mr. Prinsep's assistance I should have found my undertaking a more tedious affair than I at first imagined it. The labor involved in dealing with figures is very inadequately represented by the printed space they occupy.

rumours of wars, famines, and improved home freights have always exercised an irregular influence ; as during the past two years, the importation having jumped from 399,887 tons in 1876 to 539,533 tons in 1877, and to 609,735 tons in 1878. Had not disturbing causes, such as the Madras famine and the anticipations of war, been at work in 1877, it is probable that the imports of coal for that year would not have amounted to more than 420,000 tons, and under peaceful conditions, the figures for 1878 would have been considerably less than they actually were. Our main supply of foreign coal has hitherto been derived from the United Kingdom, the contributions furnished by other countries, with the exception of Australia and France during spasmodic periods, being insignificant The tonnage of imports for all India, from all countries, commencing with the year 1853, is as follows.—

TABLE I.—*Imports of coal and coke to India from* 1853 *to* 1878.

Years ending 30th April	1853	Coal and Coke		43,562
	1854	"		58,410
	1855	"		41,987
	1856	"	...	76,712
	1857	"		82,078
	1858	"		92,983
	1859	"	..	99,701
	1860	"	..	74,263 *a.*
	1861	"		
	1862	"		174,862 *b*
	1863	"		122,722
	1864	"	.	189,611
	1865	"		216,985
	1866	"	...	228,319
Years ending 31st March	1867	"		257,652 *c.*
	1868	Coal	368,618	385,331
		Coke	16,713	
	1869	Coal	332,718	318,926
		Coke	16,208	
	1870	Coal	.. 315,935	337,023
		Coke	.. 21,088	
	1871	Coal	.. 269,396	286,180
		Coke	.. 16,784	
	1872	Coal	... 361,960	374,184
		Coke	... 12,224	
	1873	Coal	... 310,265	324,643
		Coke	14,378	
	1874	Coal	.. 354,231	359,903
		Coke	... 5,672	
	1875	Coal	... 360 251	366,539
		Coke	... 6,288	
	1876	Coal	. 389,480	399,887
		Coke	. 10,407	
	1877	Coal	... 523,384	539,533
		Coke	. 16,149	
	1878	Coal	... 603,904	609,735
		Coke	... 5,831	

(*a*) The returns are qualified by the statement "as far as can be stated."

(*b*) For this year the returns are not complete for Bengal.

(*c*) For eleven months only.

In the following table the quota of *coals* annually supplied by each country is given for the years 1870 to 1874 inclusive, but for the succeeding periods to 1877, I have only noted the larger contributions. It will be understood that under the head of Holland, Mauritius, Red Sea, Aden, Ceylon, and the Straits, it is "transit coal" and not "indigenous coal" that has been exported for India:—

TABLE II.—*Imports of coal to India from various countries from* 1870 *to* 1877.

	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
United Kingdom ..	301,864	257,914	348,725	287,813	330,635	339,821	359,680	494,318
Australia ...	12,607	8,942	5,917	1,511	14,677	4,652	6,130	798
France ...	415	1,241	454	17,902	5,676	...	156	1,111
Germany ...	10	250	5,007	1,613	1,710	660	...	500
Mediterranean ports	...	...	..	...	275	...	...	...
Holland ...	...	...	102	...	...	...	...	...
Russia .	..	500		..	...	...	...	...
America ..	460		...	441	799	687	130	2,146
Mauritius .	...	103	...	...	...	...	...	...
Red Sea ..	...	...	...	...	50	...	...	...
Aden ...	...	120	187	136	98	...	...	...
Ceylon ...	420	363	1,386	218	207	...	...	...
Straits ...	...	...	...	187	74	...	...	...
Java	...	...	...	400	...	...	802	400
Other countries ...	159	188	182	44	30	...	...	...
Total ...	315,935	269,396	361,960	310,265	354,231	...	...	...

During the last year, the shipments of Australian coal have fallen off seriously; and I think we have now seen almost the last attempt to force it into the Indian market. For the sake of reference, I give the imports for the 20 years ended 1877:—

TABLE III.—*Imports of Australian coal to India from* 1857 *to* 1877.

		Tons.			Tons.
1857 to Bengal	...	2,271	to Bombay	...	2,176
1858	...	14,061		...	8,998
1859	...	4,278		...	2,298

TABLE III.—*Imports of Australian coal to India from* 1857 *to* 1877.—contd.

		Tons		Tons.
1860 to Bengal	.	10,008	to Bombay ..	8,112
1861 (*a*).	...	.	.	12,045
1862	...	7,191	...	5,649
1863		...		
1864	...	13,292		
1865		5,207		
1866	.	6,376		
1867		7,165		
1868	.	5,792		
1869		9,257		
1870		12,607		
1871		8,912		
1872	...	5,916		
1873	.	1,511		
1874	.	14,677		
1875	.	4,652		
1876	...	6,130		
1877	.	798		

(*a*). Returns for Bengal not given for 1861.

To illustrate the distribution of the imports to the five great Provinces of India, I have selected the years from 1870 Bombay is by far the largest receiver; the cotton-mills of the city of Bombay and the railways having their terminuses there being heavy consumers of foreign coal In Bengal the railways and nearly all the steam-mills burn exclusively the produce of the better seams of the Ránigunj field and those of the Karharbári field.—

TABLE IV.—*Imports of coal to different Provinces of India from* 1870 *to* 1877.

		1870	1871	1872	1873	1874	1875	1876	1877
		Tons	Tons	Tons	Tons	Tons.	Tons	Tons	Tons
Bombay	...	239,651	167,257	220,884	208,269	216,543	219,836	260,080	368,937
Bengal	...	42,443	63,929	89,775	48,688	82,120	63,821	61,091	76,278
Burmah	...	20,198	26,731	39,981	36,715	27,071	33,301	38,397	47,770
Madras	...	11,648	9,053	9,390	15,513	25,043	12,155	20,275	22,544
Sind	...	1,995	2,426	1,930	1,079	3,454	1,138	9,637	7,855
Total	..	315,935	269,396	361,960	310,264	354,231	360,251	389,480	523,384

Though Aden and Ceylon do not come within the official limits of India, I append the few following statistics for comparison :—

TABLE V.—*Imports of coal to Aden and Ceylon from* 1866 *to* 1876.

	1866	1867.	1868	1869	1870	1871	1872.	1873	1874	1875.	1876.
ADEN—											
Coal ..	70 361	115,572	106,265	62,610	67,546	87,394	85,158	75,569	?	74,797	99,423
Patent fuel	17,713	5,630	10,462	15,027	13,318	13,434	11,968	13,106	?	3,486	5,951
CEYLON—											
Coal ..	63,174	86,206	67,589	?	?	107,625	62,555	76,132	?	74,083	81,789
Patent fuel	8,579	2,702	9,617	4,412	14,446	11,436	6,076	4,769	?		...

Patent fuel figures to some extent amongst the imports to Madras and Bombay, but the amounts of late years have been quite insignificant

LONDON, *December* 1878

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Part 2.] 1879. [May.

NOTE ON THE MOHPÁNI COAL-FIELD, *by* H. B. MEDLICOTT, M.A., *Geological Survey of India.*

No ground in India has been so frequently noticed in these pages as the Mohpáni coal-field,[1] situated on the south side of the Narbada valley, 95 miles by rail below (west-south-west of) Jabalpur, and at the northern edge the Sátpura basin of the Gondwána rocks. It owes this distinction to three circumstances: first, to its position, close to one of the great trunk lines of railway, and as the nearest open source of coal to north-western India; its distance from Allahabad is 322 miles, or 83 miles nearer than the Karharbári field, from which all the coal for the line up to Delhi and Lahore is at present drawn;[2] and its distance from Kandwa, the junction of the Indore and Neemuch line, is 196 miles, or 122 miles nearer than the Warora colliery to the same point.

The second circumstance which gives importance to Mohpáni is, that it is the only easily accessible coal-field in this region. It has been known from the first that the only outcrop of the coal-measures along the northern edge of the Sátpura basin is at Mohpáni; and the failure of the boring experiments made during the past four years, under orders of Government, and of which an account has been published in the papers referred to above, has fairly established that the coal is not within easy reach at any other point along that line—a conclusion which indirectly gives an indefinitely increased value to the Mohpáni field.

The third circumstance which has brought Mohpáni so frequently under official notice is, the possibly precarious nature of the supply in that field. The long protracted doubt on this point has been entirely owing to the timorous and

[1] Mem. G. S. I., Vol. II, Pt. 2, 1859; Vol. X, Pt. 1, 1873. Rec. G. S. I., Vol. III, Pt. 3, 1870; Vol. IV, Pt. 3, 1871; Vol. V, Pt. 4, 1872; Vol. VIII, Pt. 3, 1875.

[2] The opening of the Palamow fields, *by the most direct line*, would remove this advantage.

inefficient management of the mining operations, especially for works of exploration, by the Narbada Coal Company, within whose property the known field lies. The mines were started at or close to the outcrop in the Sitariva river and within a short distance, in both directions, the coal was found to be cut out against two intersecting planes of faulting, the calculable amount of coal being, of course, limited to what lay in the small triangular area between these planes and the outcrop. There never was any reasonable doubt that the coal did occur outside these faults in one or other direction, or in both; and confidence in the resources of the field was sufficient to guarantee the construction of a full-gauge branch railway, 13 miles long, from Gádarwára to the pits; still, as time wore on, the urgency of proving the extent of the field became more and more pressing, so as at least to be prepared to break fresh ground before the original small block of coal-measures became exhausted.

There were two directions for these explorations: one to the south-east, to the dip of the measures, towards the main area of the basin; the other to the north-east, on the local strike of the measures. The objections to the latter ground were, that the disturbance of the rocks, already a sufficient difficulty in the existing workings, was known to be indefinitely greater to the north; and, that being also the direction of the edge of the basin, there was an extra presumable risk of original banking out of the seams. The fear in the other direction was that the measures might be let down to an inaccessible depth; but of this opinion there was no confirmation in the outcrops, which are fairly exposed in the bed of the river. These considerations were repeatedly, but ineffectually, urged upon the mining administration. The ground to the north-east was superficially the easier to explore, and efforts were chiefly spent upon it, but without the smallest success. Borings were also attempted to the south, and even a new shaft begun in that direction; but in no case was the trial carried far enough to touch the coal, even at the depth calculated from the dips, without any allowance for possible small downthrow.

When I visited the field in December 1876, in company with Mr. Hughes, the uncertainty was still pending, no advance having been made with the exploration, and the original block of measures was being rapidly worked out. The trials in other parts of the Sátpura basin were then in progress, but hopes of success were waning, and altogether the prospects of mining enterprise in this part of India seemed at its lowest ebb. When in October 1878 the last experimental trial outside the Mohpáni field had failed to prove coal, the necessity for a proper exploration of the ground within that field became imperative. To urge this point, and to see what had been done since the close of 1876, I visited the collieries in March of this year.

It was said above that there never had been any valid doubt upon the extension of the seams to the south-east; that there was no evidence for the supposition of a great fault, throwing the measures down out of reach on that side; still, until the ground was proved, anxiety could not be altogether allayed. In 1870 (see Recs. Geol. Surv. India, Vol. III, p. 69), I pointed out that "the best means of immediately testing the southern extension of the measures is from shaft No. 2," which had been long since abandoned on account of the influx of water when the coal was reached. In December 1876 an attempt was being made to fix pumping gear in this shaft; and the new manager, Mr. J. A. Maughan, M. E., who took charge of the mines at the beginning of 1877, seems to have pushed on this work with vigour, for on the occasion of my recent visit, in March last, I found that all the coal that was then being raised was by this shaft, from workings to the south, extending to about 350 feet from the shaft, beneath the covering Mahádeva rocks, and quite beyond the presumable position of any great east-west fault. In these new workings the main (30′) seam is in full force, and also the lower seam.

Thus whatever apprehension may have existed regarding the supply of coal in this field may be laid aside. The condition of the seams in the new ground opened by Mr. Maughan gives every reasonable expectation of an abundant supply, within a moderate depth from the surface.

Still the difficulties of the enterprise are not at an end. The evil effects of protracted neglect of system and forethought are not to be overcome in a moment; and the output of the colliery cannot be counted upon with any certainty until those defects are removed, and a proper system of mining established. As has been already stated, all the old openings, shaft No. 2 amongst them, are at or near the outcrop of the seams, so that the coal lies chiefly at a lower level than in the shaft; and the dip of the seam being still considerable and variable, the difficulties of raising the coal and of draining the mine increase rapidly as the work advances. Until a new shaft is in working order well to the deep of all the present openings, a large and regular output of coal cannot be depended upon.

Notice may here be given of the concluding operations in search for coal outside the Mohpáni field, in continuation of that given in the Annual Report for 1877 (Rec. Geol. Surv. Ind., vol. XI, p. 7). The Anjan boring, mentioned as then in progress, was carried to a depth of 350 feet (11th May 1878) without piercing the covering red rocks of the Mahádeva series. This was the last trial to find the coal-measures in proximity to the detached inliers of the Talchirs.

There remained but one position favorable for a trial, and where, I must confess, I looked with very great hopes for success. It is close to the south-east of the village of Baner, or Benár, at the very edge of the Narbada Company's land, in ground formerly held by the Sitariva Coal Company, when a shaft had been begun, by my advice, at this spot.[1] It is less than half a mile from the seams in the Sitariva; an outcrop of coal-measure sandstone (or a rock undistinguishable from it) occurs north of the village, and the shaft begins in the red covering rock, so that unless the coal dies out within that short distance, or some undetected unconformity occurs between the formations, there seemed a certainty of striking the coal here, and I recommended to Government that a boring should be put down in continuation of the old shaft.

This boring commenced on the 24th February 1878, the water and mud having been cleared from the shaft, which was found to be 118 feet deep,

[1] See Rec. Geol. Surv. Ind., Vol. IV, p. 68.

and the bottom 13 feet, which was not walled, consisted of purple clay, brittle and falling off in flakes. At 179 feet the red rocks were passed through. The dip and the distances from the boundary not being accurately known, on account of the covered nature of the ground, no exact calculation could be made; and in such massively-bedded rocks any such calculation could only be approximate; but at a probable estimate of a dip of 20° and a horizontal distance of 500 feet, this proved depth and thickness of the Mahádeva rocks is about what should occur under the assumed condition of conformity; and at least it proves that between this spot and the boundary there can be no great post-Mahádeva fault, with southerly downthrow.

At 179 feet the boring entered on sandstone, grey and white, felspathic, most like the coal-measure rock; and our hopes were very strong that coal would soon be struck, as, in the supposed normal section, it all lies within the top 150 feet of the measures. Carbonaceous shale and even fragments of coal appeared in some of the samples, but only to delude our hopes, for the boring was continued to a depth of 426 feet, or 247 through the lower formation, without any better result, so I recommended the work to be stopped.

In attempting to account for this section, several conjectures are apparent. It may be that the carbonaceous measures passed through are not the true coal-measures, but only the carbonaceous measures of the middle Mahádeva horizon, such as were found at Tundni, eight miles to the west; but the total absence of such beds in the clear section in the Sitariva, within half a mile of the boring, makes this supposition the least probable. There is then the possibility that within this short distance the coal seams may have died out; this is the most unfavourable view of the case, and one that seemed unlikely, considering the great regularity of the bottom seam in the lower mine, north of the river; but it is a chance that must not be lost sight of in our Indian coal-fields, especially in these lower measures; indeed, in this same bottom seam, I have observed something very like an original extinction, in the section of the "new incline," where the coal passes rapidly into a sandy shale, never having come to the surface on the rise of the little hill. A third supposition is, that the boring chanced upon a band of disturbance, and so passed down between the broken and displaced seams. The mixed nature of the samples at and below a depth of 325 feet gave some support to this supposition, and it was the one I felt inclined to adopt.

The facts disclosed by the new working at the mines dispose me, however, to think that we have here to deal with original features of the deposits. The lie of the seams south of shaft No. 2 is not quite what would be inferred from the outcrops: the strike is more nearly due south; and in rising to the west the coal is stopped out against a steeper sloping face of sandstone. Mr. Maughan has had to deal with many slips and crushing of the seams in these new workings, but they have all proved only temporary obstructions, save this one on the west. To prove it thoroughly he had a boring put down from the surface at a point about 200 feet west of this stoppage. At 140 feet the red rocks were passed through; here again, as at Baner, this depth indicating the general conformity of the groups. Below 140 feet the bore passed through 270 feet of coal-measure rocks, "grey post and blue metal," *i., e.*, sandstone and dark clay, to the total depth of 410 feet, without a sign of coal. We can hardly again have recourse to the conjecture of a space between faulted ends of the seams. The one supposition that meets all the local facts is that of original limitation.

I said above that this is the least favourable view to take, as of course if the interruption were only due to faulting, the recurrence of the seams could be counted on, whereas no diagnosis of the ground can do more than guess at variations of original distribution. I do not think, however, that there need be any alarm on this score for the immediate, or even for the distant future. I cannot but think that there must be a great store of coal beneath the Malpi (Mulpee) plain, and south of it up the valley of the Sitariva.

ON PYROLUSITE WITH PSILOMELANE OCCURRING AT GOSALPUR, JABALPUR DISTRICT, *by* F. R. MALLET, F. G. S., *Geological Survey of India.*

The existence of manganese ore at Gosalpur appears to have been known for a long time past, and the mineral has been in use to some little extent amongst native glass makers in the neighbourhood. It was first brought to the notice of Government by Mr. W. G. Olpherts in 1875, to whom we are indebted for specimens subsequently received. Lately, the Deputy Commissioner, Colonel Playfair, has again called attention to this ore and asked for information regarding it. Within the last month Mr. Medlicott has visited the locality, and reports upon the deposit as follows:—

"The sections available for examination were very poor indeed, only shallow holes, 5 or 6 feet deep, along an irregular line some 20 yards in length, on the outskirts of the village of Gosalpur, at the base of the low ridge on which the dák bungalow stands. The well in the village, from which also the ore was obtained, is at a slightly lower level, about 120 yards nearly due east of the shallow pits, but it was not available for examination. I have, however, satisfied myself that the deposit is not a vein or lode, and that it has no apparent connection with any vein or lode in the underlying transition rocks. It is not, either, a layer or bed in the formation in which it occurs, which is laterite, but is irregularly distributed throughout this rock in lumps of various shapes and sizes. These mostly have a spongy or cellular structure, but some pieces of very compact ore, more or less reniform, were found. This laterite is of the older type: at least in the exposed sections I could not detect any palpable debris, which generally characterizes the secondary or detrital laterite. It is therefore presumable that the lumps of ore are innate, and that the manganese is an integral component of the laterite in this position. The ore in the little pits is at a higher level than in the well, which is still in laterite at the water level, 45 feet from the surface, and where the ore seems to occur at any level. It is, I think, reasonable to conjecture some local source for such an unusual ingredient in so wide spread a rock as the laterite; but the underlying rocks are greatly concealed by the laterite itself, or by alluvium, and no vein of this mineral may be found in the few exposed outcrops: manganiferous iron ore is, however, known to occur in these rocks, more to the north at Mogála and Jauli.

"Although the nature of the deposit is thus more or less obscure, I see no reason to doubt that a large supply of this ore may be depended on at Gosalpur."

The ore is dark steel gray, finely crystalline, pyrolusite, mixed with a varying proportion of psilomelane. Some lumps are almost free from the latter mineral, others contain a considerable amount; but on the whole the psilomelane is very subordinate to the pyrolusite. The exterior of the lumps, and the surfaces of most of the internal cavities are more or less coated by oxide of iron.

A carefully selected average sample of the ore yielded on analysis—

{ Manganese calculated at protosesquioxide	75·86
{ Oxygen	9·96
Iron, sesquioxide (with trace of alumina)	4·53
Baryta	3·55
Phosphoric acid	·28
Insoluble in hydrochloric acid	2·74
Combined water	2·41
Hygroscopic water	·28
	99·61

The ore contains 54·66 per cent of manganese, and 3·17 of iron, with ·28 of phosphoric acid and no sulphuric acid. It contains 15·26 per cent of available oxygen = 83·00 per cent of peroxide; as an oxidizing agent, therefore, it is of high value, the average run of manganese ores met with in commerce containing only 60 to 75 per cent. The percentage of peroxide in the ore, calculating all the manganese as peroxide, would be 86·42 per cent., but the presence of some psilomelane reduces the available percentage about 3½ per cent. The insoluble residue is chiefly, or entirely, silica. With reference to the presence of baryta, a substance so commonly met with in psilomelane, and not unfrequently in pyrolusite, it may be mentioned that baryta in the form of barite occurs in some quantity at Imlia near Sleemanabad, 20 miles north-east of Gosalpur.

A GEOLOGICAL RECONNOISSANCE FROM THE INDUS AT KUSHALGARH TO THE KURRAM AT THAL ON THE AFFGHAN FRONTIER, *by* A. B. WYNNE, F.G.S, &C., *Geol. Surv. Ind.*

In volume X. of the Records, I gave a sketch of the distribution of the tertiary rocks in the N.-W. Punjab.[1] In that account, and in the map accompanying it, the ground immediately along the Affrídi frontier is omitted. In order

[1] The information given regarding Upper Punjab geology, by the Geological Survey, being somewhat scattered, I may mention that the most important areas as yet examined will be found referred to, besides the above, in Memoirs Geol. Sur., Vol. XI, pt. 2 (Trans-Indus Salt Region), also Qrtly. Jnl., Geol. Soc., Lond., Vol. XXX, p. 61, and Vol. XXXVI, p. 347; a memoir on the Salt Range, Mems. Geol. Surv. Ind., Vol. XIV. On the neighbourhood of Murree, Records, Vol. V, pt. 1, and Vol. VII, pt. 2. On Jamú hills, Records, Vol. IX, pp. 49 and 155. On part of Upper Punjab, Records, Vol. VI, pt. 3. On Kharian hills, Records, Vol. VIII, p. 48. On Sirban, Memoirs, Vol. IX, pt. 2.

to fill this gap, as far as possible, taking advantage this season (1879) of my camp being on the frontier, after visiting the continuation of the Salt Range beyond the Indus, I carried observations as far as Thal. Owing chiefly to circumstances connected with the present Affghan campaign this country, always more or less subject to frontier difficulties, presented others regarding scarcity of supplies, necessitating a rapid inspection of the ground.

The whole of the country immediately to the east and south is within the limits of the great fringing belt of tertiary rocks which borders, where it does not form, the outer hills of the Western Himalayan area (taking this in its extended sense to include all the most northerly Cis-Affghan mountains of the Punjab). These tertiary rocks of the neighbourhood embrace the upper and lower Siwalik sub-divisions of the newer mechanically formed beds, and also very extensively the underlying older tertiary "Murree group," and the eocene (Subáthu) limestones; the two last passing into each other by alternation, and the limestones becoming largely developed westwards in the Kohát salt field.

The whole route from Kushálgarh to Thal lies in the Subáthu zone, for 93 miles. Cis-Indus, all along the northern margin of the Ráwalpindi plateau, the country is traversed by what I have called the abnormal junction feature, forming the inner boundary of the outer tertiary zone; it is coincident with the base of the first high hills rising to the northwards; but further west, trans-Indus, though the same physical relations continue, of lofty limestone mountains, comprising various mesozoic and eocene groups, bordered to the south by inferior hills of tertiary age, this junction feature has not been examined, because the higher mountains at the base of which it should occur are all but entirely occupied by the wild Affridis, Zhúwakkis, Akhor Kheyls, Urukzais and other *Yagi*, or independent tribes, whose country is closed to Europeans by British authority, as strictly as Chinese Tibet is by the officials of that region. Discordance of one kind or another is the strongest characteristic of this junction feature, by some regarded as a line of fracture, by others as an unconformity marking a limit of deposition, traceable from the N.-W. Punjab to the Simla area of the Himalayas, possibly much further, and analogous to a very similar feature in the structure of the outer Alps. It dates from the Himalayan mountain-forming disturbance, posterior to earliest eocene times; and it is remarkable that, although some appearance of a transition from the older nummulitic limestone masses north of the line into the newer and more markedly nummulitic beds to the south has been observed, these newer beds have been but doubtfully distinguished north of the junction in the Upper Punjab. The weight of evidence, such as it is, goes to show that the upper nummulitics ranging south of the junction were, if at all, but sparingly deposited and capriciously distributed over the region to the north; nor is it at all certain that the nummulitic beds north of the junction may not be but a local development of older eocene limestones along the inner (northern) side of the tertiary zone.

Kushálgarh, where the Indus is now crossed by a bridge of boats, is the locality given for some mammalian bones and teeth, formerly miscalled the Attock fossils, which present certain differences from Siwalik forms, as pointed out by Mr. Lydekker in these Records, Vol. IX, pt. 3, Pal. Ind. Series X. 2. The exact place whence these fossils were procured is unknown, and several efforts to rediscover it have failed.[1]

The rocks of the neighbourhood are on the horizon of the lowest Siwalik or uppermost Murree beds, here quite impossible to separate by any distinctive petrological character, a difficulty increased by the scarcity of fossils of any kind. The existence of fossil timber, however, which is found in the lowest of these groups, though not always present, may indicate the rocks belonging to the older group of the two.

The ground, though open, is ridgy and rugged; the beds are highly inclined to the north or vertical, and run in directions from E. and W., to N. E.—S. W.: they include soft and harder greenish and gray sandstones with red, purple, and occasionally gray, alternating clays. For several miles westward of the Indus, its characteristic gneiss and metamorphic pebbles are thinly scattered over the country; but I was unable to find a single erratic, *i. e.*, travelled block or boulder such as are so numerous across the river about Jand, &c.

Eight miles to the northwards are hills of nummulitic, limestones of the Subáthu character, bent up in compressed folds, and associated with dark shales, red clays and gypseous masses. Sulphur and petroleum springs occur, closely connected with the upper zones of these limestones and clays, as on the right bank of the Indus, near Dandi hill station (where there are appearances of once extensive sulphur or alum works), or issuing from the solid limestone in the Ungo pass.

About the same distance still further northward, the main inner boundary of the Murree and Subáthu zones is over-slipped by the hill nummulitic limestone of Nilábgásh mountain, which rises immediately north of the abnormal junction feature, and includes amongst its beds jurassic, if not other secondary rocks.

Westward of the ground intervening between this and Kushálgarh, the country is apparently complicated, alternations of the limestones with red rocks of Murree aspect, displaying themselves largely in the southern part of the Zhúwakki Affrídi hills.

From Kushálgarh westward the general surface rises towards the commanding hill of Gurgurlot, the summit of a range which, with the exception of rock salt, repeats all the essential points of structure observed in the ridges of the Kohát salt field.

Approaching this hill, the purple and red rocks show much contortion, and fold round the greatly disturbed double anticlinal curvature which occupies the range, but so misshapen, crushed and twisted that the original simplicity of structure is greatly obscured. The axis of these folds run from N.-E. through S.-W. to a westerly strike. Just north of the Gumbat pass another ridge of nummulitic limestone includes, between itself and Gurgurlot, a set of the dark purple and red sandstone and clay beds of the Murree group, as a synclinal

[1] Bones seem to be specially uncommon among the beds of Kushálgarh, perhaps all the more reason for their occurrence in numbers in some local layer. Such a situation is said to have been found several years ago, 3 miles west of the village, in a cutting for the Kohát road, near a *búrj* or watch-tower.

fold. The very lowest of these, at their contact with the last-mentioned limestone, contain bones. Rib bones and fragments only were found, but unfortunately no teeth. The occurrence of these so low in the series shows, however, that the bone beds of the Punjab are by no means limited to the upper (or Siwalik) groups.

It is on the southern side of the Gurgurlot range, at Koteyri, that an extraordinary example of complete inversion occurs, placing the eocene limestone for a width of more than a furlong above the next newer group of sandstones and clays (see Trans Indus Salt Region, Mem., Geol. Sur., Ind., Vol. XI, pt. 2, p. 20.)

Besides the ordinary succession of the salt region tertiary beds, bands of flaggy limestone here appear in the gypsum, having the curious structure called cone-in-cone, very perfectly developed.

The general succession observed in and near the Gurgurlot range is as follows (in natural order):—

Lower Siwalik	5 Soft greenish-gray sandstones, with bones, and red clays; the sandstones sometimes conspicuously massed together.
Murree beds	4 Purple sandstones and bright red or purple clays.
Eocene Sabáthu	3 Alveolina and other fossiliferous limestones.
	2 Red clay zones of the Salt Region to the south.
	1 Gypsum in massive beds and masses, with layers of dark flaggy limestone and dark grayish clays.

Some of the springs on the southern side of Gurgurlot are said to be saline, more so at times than at others. The range declines to the westward, being connected by lower limestone ridges with the higher ones of the Bangásh hills. Both the latter and the low ridges mentioned expose here and there, interstratified with the limestones, clay and sandstone bands, having entirely the ordinary aspect of the Murree beds, but sometimes including coarse sandy calcareous layers enclosing nummulites, or bands of olive clay. An alternation of this kind is seen at the little pass on the Kohát road north of Lachi.

In the neighbourhood of Gumbat the low ground seems to have been eroded chiefly, if not entirely, from the sandstones and clays of this part of the lower tertiary rocks; and in every escarpment of the surrounding country, the red rocks are seen to underlie the limestone portion of the ridges. This appearance is as strongly seen as anywhere along the northern side of the Gurgurlot ranges; yet when followed eastward through the Gumbat pass, these red rocks are plainly resting upon the limestones.

Accepting this as the normal order, it would be easy notwithstanding appearances to suppose the limestone in all cases, or nearly all, the oldest rock. But further west this is found not to be the case, several alternations of the limestones and sandstones of different thicknesses taking place; so that it becomes exceedingly difficult to find the true positions of these limestones and red rocks where the sections are isolated or much contorted.

From Gumbat to Kohát the road passes for 8 miles through an open earthy or stony country of alluvial flats, terraces, and undulations exposing either the lower tertiary sandstone and clays, or limestones; the Gurgurlot range lies to the south, and the rugged hills of Zhúwakki land are approached to the north, showing long edges of limestone cropping out above the red Murree-like rocks.

Nearer to Kohát, about Billotang, low barren limestone hills are entered, showing many undulations of the beds at all angles up to vertical, and several of these again exhibit the same alternation of the limestone, sandstone and red clays. A low ridge from these hills stretches towards Kohát, in front of the lofty and highly contorted or partially scarped limestone mountains of the Affrídis, crossed by the hired pass from this country to Peshâwur.

The remainder of the distance to Kohát (15 miles from Gumbat) is through flat irrigated country; but in the ascent from the station to the pass just mentioned, dark arenaceous and rusty impure limestones, containing jurassic and cretaceous fossils, are folded amongst the dark gray nummulitic limestones of the hill type; and the line of abnormal junction traverses the country from east to west along the southern face of the Affrídi hills. Further north, within the pass, much of the gray limestone everywhere visible may be of triassic or at least mesozoic age; a sufficiently close examination to decide this was prevented by political reasons at the time I traversed the pass.

At Kohát one is close to the frontier, the much folded and contorted limestone wall of the Affrídi mountains, rising abruptly from the northern side of the Bangásh, or Kohát Towey, valley and attaining greater elevation as the mountains run westward. The station is built upon a stony rising ground, one of the many fan-like accumulations of subaerial detritus at the mouths of the mountainous valleys of the Upper Punjab[1]. The situation, the vicinity of a mass of limestone mountains, and the presence of coarse stony superficial deposits, are all favorable towards the existence of the remarkable springs which occur here; a large one, over which a musjíd has been built, sends forth a perpetual great stream sufficient to turn the wheels of several mills, and to water the whole station. Looking towards the Bangăsh valley, famous for its fruit trees, its limpid streams, and the cutting cold wind which blows down it on winter mornings, the high mountains lie to the north, and a long ridge, also of limestome, terminating eastward in considerable rugged eminences, closes it in on the south. This southern ridge is of fossiliferous upper nummulitic limestone, overlying a thick band of such gray sandstones and red clays as are common in the Murree group, the whole dipping rather steeply to the south. The only spot at which the northern limestones could be inspected was near a group of ruins, some 4 miles from the station, perched nearly on the top of a minor spur. The limestones here were found to contain dark and rusty beds distinguishable even from the road, amongst which *Belemnites* and fragments of other cretaceous *Cephalopoda* (as determined by Dr. Waagen) were observed. The beds as usual appeared to be folded, but from a distance the whole face of the mountains presents sufficient of a northerly dip to give them a decidedly scarped appearance. Here also were found the ordinary features of the line of abnormal junction: on one side nummulitic limestones interstratified with red beds of the older tertiary aspect; and on the other, different hard limestones, including bands containing jurassic

[1] Finely displayed, I am told, along the upper waters of the Kurram river in Afghanistan, as seen from the Peiwar Kotul route.

and cretaceous fossils, the beds dipping diversely and presenting the appearance of fractured displacement.

The valley is narrow, scarcely a mile in width, the frontier line sometimes not more than half that distance from the road, and the surface is formed of a drab saline clay soil or alluvium, apt to harden at first on drying, then to pulverise into fine dust, and to form rapidly deep fluid mud on the access of rain. Near the village of Kuz-Usturzai,[1] the main stream is joined by another from the valley of Samilzai and Murrai, which re-enters the mass of the mountains to the northward for some 8 or 10 miles, and might therefore be likely to expose something of their geological relation. As is not unusual along the frontier, this recess containing some cultivable ground, is included within the British boundary, the "red line" leaving the mountains outside; still it was considered expedient that I should not enter the valley without an increased guard and special arrangements, which the pressure of circumstances precluded. So far as could be seen, the ground within it was traversed by low limestone ridges, partly continuous with, and partly repeating, the features of the adjacent part of the main valley, where nothing except eocene beds were recognized. On the north-eastern and northern sides of this Murrai valley, the lofty limestone escarpment from the neighbourhood of Kohát was observed to sweep along, broken by ravines and plateau-like summits, towards Khuyukkai Sir, culminating some miles to the westward at the tabular summits of Mazzeoghar and Dupah Sir,—the latter over 8,000 feet in height, faced to the south by stupendous cliffs, and overlooking the high valley of Tirah to the north.

In these cliffs strong zones of gray limestone, alternating with much softer thick bands, probably of shale, could be seen dipping at angles of 30° and 40° in northerly directions, the dip becoming more marked and steeper in the same direction, away to the westward. The stream coming from these mountains brings down pebbles chiefly of dark gray limestone in which fossils are concealed or absent, but the rock looks and smells like the hill variety of the nummulitic limestone; there are also a few of light-coloured fossiliferous nummulitic limestone, others of a greenish semi-oolitic limestone, containing parts of bivalve shells with strongly marked umbones and many large blocks of hard white quartzite sandstone.

The road to Hangu rises from the alluvium of this stream on to flat-topped *Karewah* hills, formed of horizontal boulder conglomerates, from 40 to 100 feet thick, beneath which are vertical grayish dull sandstones and bright red clays. These last are seen again edging the bases of long low nummulitic ridges to the northward, which dip into the valley in various northerly directions. It here becomes evident that the Hangu valley is excavated upon the softer much disturbed red clays and sandstones underlying and interstratified with thick zones of the Alveolina and other upper nummulitic limestone, the whole arrangement being not unlike that of the Subáthu beds in many places along the north of the Ráwalpindi plateau, but on a much larger scale. Deep excavation in the valley beds and the stony hills they form continue to the camping ground of Sherkot, 12 miles from Kohát, and there is nothing in the structure of the ground within British territory here to mark the westerly continuation of the discordance

[1] Commonly called "Sthoorzee" by the natives.

between the nummulitic beds of the vicinity and the limestones of the mountains to the north.

In the next march, to Ibrahimzai (8 miles), another stream from the northern hills, having a long easterly course from behind the Samána ridge, is crossed at Raiss; the boulders in the stream being of similar kinds to those previously mentioned. The valley here becomes much more confined and hilly, and at the fifteenth mile from Kohát is obliquely crossed by the ridge which has hitherto bordered it on the south, the river finding its way through a deep gap called Khwajahkhozal. In the ascent to where the road is led through this pass, on the northern bank of the stream, as in some hills to the eastward, the more solid limestone of the ridges is seen to overlie compact lumpy gray or drab Alveolina limestone, which rests upon strong gray sandstones immediately overlying thick red clays; the whole folded into an anticlinal and synclinal curvature. From the top of the pass to its western opening, an ascending series with a dip of 50° or 60° is exposed, thus—

Upper nummulitic.	Red clays; remains of a band several feet thick.	
	Strong nummulitic limestones, overlying ...	234′
	Greenish shaly and softer beds, concealed by talus ...	219′
	Red clays.	Obscured.
	Thick alternations of strong bedded and shaly limestone and greenish shales; layers of the limestone crowded with fossils	258′
	Grayish and purplish sandstones with red clays ...	over 100′
		811′

Westward of the pass the valley again slightly opens, and on its south side higher beds of the limestone, overlying red clays, &c., with a southerly dip, form a ridge extending nearly to Ibrahimzai. About this village all the much disturbed high-cliff-forming limestone ridges strike westward obliquely across the valley to the flanks of the Samána ridge.

From Ibrahimzai to Mirkhweli (the hill sanitarium for Kohát, having an elevation of 4,700 feet), 5 miles to the south-east, many alternations of the limestones, clays and sandstones are exposed, at first nearly vertical, then forming a wide synclinal basin, over the central, east and west, axis of which is the little station of Mirkhweli. All these beds are higher in the series than those of the succession given above, and have an estimated thickness of fully 4,000 feet.

The northern slopes and precipices of these hills are much concealed by a jungle, often densely luxuriant, of *Kao*, *Fullái*, *Mazzurra* (dwarf palm), *Sunhetta* and other bushes, sometimes attaining the growth of trees, and supporting vines. Hence the thicknesses of the zones in detail are not readily distinguishable, though they may be roughly stated at from two to four hundred feet. The following series was here made out (natural order) :—

FIG. 1 (*see Map*).

14. Small limestone cap on summit of Mirkhweli.
13. Purple clay zone, under the Deputy Commissioner's house.
12. Thick capping of gray Alveolina limestone, forming the general hill top.
11. Red and purple earthy and sandstone rocks of the aspect of Murree beds.

Numerous fragments of a gray (green-weathering), coarse calcareous sandstone, conglomeratic with fragments of quartzite and white hornstone, are scattered over the slopes of Mirkhweli formed by this zone; its presence *in situ* here can scarcely be doubted.

10 Very thick zone of gray Alveolina limestone, defining the basin and forming the summit of Spirkhwet hill.
9. Red clays.
8. Very thick band of olive clays.
7. Dark ferruginous and greenish gray conglomerate, pebbles, white chert and quartzite.
6. Compact nummulitic and Alveolina limestone.
5. Red clay, overlying bands of dull sandstone.
4. Thick olive clays or shales.
3. Red clays.
2. Strong ridge of gray limestone.
1. Red clays and dull-coloured sandstones, a thick band, overlying limestones of similar kind as above-noted.

Beneath these last mentioned limestones are the uppermost beds of the succession previously given, so that this part of the Sabáthu group appears to have a thickness of 5,000 to 5,500 feet, roughly estimated.

From the summit of Mirkhweli, looking northwards, a fine view is obtained of the lofty limestone mountains, with the lower Samána ridge in front, forming a marked anticlinal curve, its southern side being sheeted with inclined curving beds of bare rock dotted with scattered jungle, while the ranges behind continue the northern slope of the curve. The alternation of gray limestone and thick softer zones is very visible, but nothing redder than the colour of the withered *Bubber* grass could be seen by the aid of a field glass. These mountains in Urakzai are so high, that even from this elevation (2,000 feet by aneroid above Ibrahimzai, and 4,700 feet above the sea), but little of the Sufed Koh, away towards its peak of Sikaram, could be seen.

In the opposite direction Mirkhweli dominates all the numerous limestone ridges and valleys occupied by the red rocks, &c., of the Kohát salt field.

From Ibrahimzai to Hangu the valley narrows and seems blocked by overlapping profiles of limestone ridges, one of these, north of the road, again showing distinctly a thick intercalated band of the red rocks between two limestone zones. At Hangu the latter is dark, containing but few fossils, and dips strongly to the north-east. Here a small valley running northwards reaches the Samána anticlinal beyond the frontier. By sending a messenger into this forbidden ground, I obtained specimens of dun lithographic textured limestone, some without fossils, but one full of *Alveolinæ* which was stated to have been taken from the southerly sloping beds of the ridge. Others were of white sandstone, rusty externally, the position of which was shown as a band along the foot of this Samána ridge. This white sandstone is identical with the blocks in the streams near Sherkot.

The hills south of the valley at this place are rugged, jungly, and grassy limestone masses, evidently continuing the undulation of the Mirkhweli section. At this part of the valley the soil has changed colour to darker brown and black tints, the cause of which is not very evident.

From Hangu to Togh, 34 miles from Kohát, the valley opens out considerably, the Samána ridge trending to the N. W., and long terrace-like mounds or fans are seen along its north side, similar to those observed in the Teri valley to the south (Mem. Geol. Sur., Vol. XI, p. 109). The frontage of the northern hills still shows the anticlinal slope of the Samána ridge, overtopped by the scarped edges of the beds in the mountains beyond. South and south-westward the samé features continue as were noticed from Hangu; but a depression in the crest of the nearest range allows other parallel ridges with long horizontal outcrops of limestone to be seen beyond.

From Togh to Suruzai, 11 miles, the valley becomes still wider; its crest is passed at Kai, and the Zwymukht valley joining it from the north-west, the superficial waters unite to form the Shakkalli stream, which falls into the Kurram below Thal.

Most of the ground is covered with low accacia and Mazzurra jungle, and two lofty clusters of limestone mountains are seen to the westward, one the Dano hills over Tarawari and Darsamand, the other the Kadimuk group immediately north of Thal camp.

Near Togh, at the village of Bar, a mass of green clays with harder calcareous mudstone layers shows itself, dipping at 60° beneath the limestone of the southern side of the valley; it appears to be more than 200 feet thick, and has white *kallar* efflorescence, but no fossils could be found in it, its aspect is not unlike the *Sheor Kowra* clays of the Kohát salt field. This band seems to follow the course of the Shakkalli stream the whole way to and below Thal.

Near Kai there are long flat-topped, slightly hanging, terrace-like detrital hills, and on the "divide" between the Shakkalli and Kohát Towis there are some outcrops of dark green coarse gravelly and fine olive quartzose calcareous grits; these beds weather black, and the gravelly ones contain little fragments of limestone, mostly angular. Over these are green clays, similar to those at Bar, with purple bands and hard sandstone layers; the group is evidently much folded, on east and west lines. It is not improbable that the large valley here has been mainly excavated from these rocks, which possess more or less of a Subáthu aspect, but yielded no fossils except some broad striated plant impressions.

North of this the Samána ridge appears to inosculate with the higher limestone hills, the scarps of which, running west by north for the summit of Zawaghar (9,380 feet), still shew prominently two or more broad zones of shales, or other soft beds, between the harder ones of limestone, the dip having now come round to north-by-east.

To the west the Dano and Kadimuk mountains both show great anticlinal axes to the south, with strong northerly dips at 45°, and inner folds along the lesser elevations, uniting them with the Urakzai mountains northwards. To the south the rolling nummulitic limestone hills still shut in the valley extending nearly as far as Gandior, 54 miles from Kohát.

In the streams from the northward between Kai and Togh, I found numbers of light-coloured sandstone blocks, some of dark green quartzite, and many dark gray limestone pebbles, some of which contain shell fragments. Fragments of a dark gray limestone, weathering deeply to a brown colour, contain fragments of *Rhynchonnella* with smaller bivalves, and a dark conglomeratic semi-oolitic calcareous grit, with white quartz in scattered grains, was found to enclose *Belemnites.* This stream comes from the highest part of the Samána ridge, where there is at least this evidence of the occurrence of the mesozoic rocks. The beds of streams further west towards Suruzai and Doaba are largely filled with gray shale detritus; one coming from Darsamand also contains dark sandstone fragments enclosing *Belemnites,* and the soil is frequently dark coloured or blackish recalling the cotton soil of the Deccan.

From Suruzai to Gandior the character of the country is quite the same as just now described. Crossing the Mazzurra-covered plain from Gandior to the Darsamand mountain, near the base of the latter, greatly disturbed, dark rugged limestone with small nummulites and the little Rotalina characteristic of the eocene hill limestones are first seen. Some of the beds have a conglomeratic structure enclosing limestone lumps. A band of sandy limestone also appears, and then green quartzose grits, weathering to a black metallic colour. Beyond these is a strong rib of thick and thin-bedded compact gray limestone without fossils, dipping at high angles northwards and underlying a band of dark greenish and rusty olive or whitish hard coarse silicious sandstone, the dip of which is 50°. Similar sandstone and hard olive shaly beds occur on the further side of a hollow as if faulted against massive blue limestone, with a southerly dip at right angles. Sheets of this stretch up the mountain side forming the southern slopes of the anticlinal curve before mentioned. No fossils were found *in situ* in these limestones, but fragments from the hill contain *Rhynchonnella,* oysters and *Chemnitzia*-like spirals, and have a semi-oolitic structure.

Here all similarity to the nummulitic limestone has vanished, and a fault evidently separates the latter from the rocks of the hills. Moreover, these at the point struck must belong to a middle portion of the hill section, for the axis of the anticlinal bending downwards brings in higher beds to the eastward, likewise checked against the low outer rib of limestones, &c., having a northerly dip.

The fault here may be the great fractured junction feature of the eastern Upper Punjab section, but a hasty glance was all that could be obtained at the ground, the frontier lines here, as is often the case, being rather hypothetical. Between Gandior and Thal (63 miles from Kohát) this long valley, through which a main route from Afghanistan has lain since the time of Baber, becomes again narrow, though joined from the north by the Singroba glen. The mountain masses of Dano and Kadimuk shut out the more distant ones to the north in a great measure, and the southern side of the valley is no longer formed of limestone, but of almost horizontally bedded sandstone and clays, partly of the Murree group, and partly of Lower Siwalik aspect, the continuation of those occupying the Dallan valley. (Mem. Geol. Sur., Vol. XI, p. 101.)

At the southern bank of the river, not far from Gandior thannah, is a mass of limestone conglomerate with all the appearance of the usual valley beds, in a consoliated state, but it dips at 60° to the north-west, resting on or against greenish and purple clays, which come out from beneath the nummulitic limestones. The position of this conglomerate may perhaps be accounted for by supposing an old consolidated terrace to have been undercut by the river, and to have subsided into this sloping attitude by its own weight. If not, the occurrence is remarkable.

The walled village and the camp at Thal are situated at the confluence of the Singroba stream with the river Kurram, and upon coarse detrital river accumulations of the local rocks. The elevation is supposed to be about, or somewhat over, 2,000 feet. Within a mile of the camp to the north, the high mountain of Kadimuk shows a short east and west anticlinal axis, around which the strong-bedded limestones form an elliptical quaquaversal dome.

Favoured by Colonel Gordon, commanding at Thal, with an extra guard, I was enabled to visit the lower part of this mountain. On the way there an exterior group of hills was crossed, composed of contorted, vertical and much disturbed, hard olive and gray quartzose sandstones, covered with a dark metallic lustrous film, and green, gray or purple clays, some of which are exceedingly fine and hard, with a splintry structure. Subordinate beds and bands of marly limestone also occur. Some of the latter contain well-preserved corals of two or three species, and in one bed of the externally dark-coloured sandstone I observed a few casts of small echinoderms.

Among the lowest beds of this exterior (? lower Sabáthu) group are unequally coarse sandstones, enclosing fragments and large blocks and blotches of limestone. Nearly in the same strike I also found a thick bed of limestone conglomerate, apparently reconstructed from such limestones as those of Kadimuk. The base is sandy, and lying on the rock, as if weathered out of this, a fragment of a *Belemnite* was picked up. Notwithstanding the interstratification, there is in consequence of the occurrence of this bed some appearance of a break low down in the group; but the relations of this to the rock of Kadimuk are those much more of faulted discordance than of unconformity. The whole outer group, in spite of the faulted appearance, sweeps round the axial western dip of the high mountain, and for some distance from the river strikes up the left bank of the Kurram.

At the southern base of the mountain a thin band of the dark-weathered sandstones, &c., separates a considerable mass of gray limestone from the Kadimuk anticlinal. This limestone has an uneven texture, showing small black specks like minute organisms, with a few narrow spines. Such limestone is not uncommon in the lower hill-nummulitics of the region north of Ráwalpindi plateau.

In the strong limestones of the mountain I found no fossils *in situ*, but fallen fragments contained anneloid tracks, oysters, bryozoa, or small corallines and corals, many small gastropoda, some like *Nerinœa*, and a few sections of impacted little bivalves, the aspect of the whole being that of older limestones than any of the eocene ones I am acquainted with.

One of the officers of the Kurram force (Mr. Macleod, 29th Punjab Infantry) informs me that some time ago near the summit of Kadimuk, beneath a limestone cliff, he found several ammonites lying on the surface of a softer band. I was unfortunately not able to procure any specimens of these, even through an inhabitant of Thal who knew where they are; for it appeared that part of the mountain was occupied by a wandering party of Ghilzais with whom the people of Thal were at feud.

Immediately across the Kurram, on the Afghan side opposite to Thal, is the very rugged hill of Bakkarkanch (flint-stone), entirely different in appearance from any of the neighbouring ones. It is chiefly formed of masses of hardened and altered brecciated beds, some being altered limestone or a silicious rock full of angular fragments of hornstone or flint,[1] usually mottled or banded with reddish or dark purple and gray tints. Others enclose also angular fragments of white earthy limestone, as if the whole had once formed flaggy beds; but the fragments now lie at all angles in the rock. Between these beds are purple, flaggy and gray or greenish shaly bands of Subáthu aspect, layers of a ferruginous red lateritic rock, and some of very hard thin-bedded limestone without fossils. The beds are broken into disconnected masses, and the cause of their alteration is not far to seek, for everywhere through the hill are numerous intrusions of hard, dark or decomposed, variously coarse, crystalline, syenitic and compact trap, weathering down so as to be less prominent than the silicious altered rocks. Looking from one of the summits towards the westward, a large space among lower hills was seen to be occupied by cores of the dark crystalline trap, the chief sources of which may be in this direction.

Besides the dark solid traps there are also what seem to be masses of agglomerate of trappean fragments, and fine-grained tufaceous traps, alternating in beds or layers. It was not found possible to recognise such an association of these lava-like rocks with the altered ones as would establish contemporaniety; but the entire assemblage has the mixed appearance one would expect to find near the core of a denuded volcanic vent.

Just beneath and in the under surface of one of the brecciated bands near the top of the ridge, old excavations were shown, made along the outcrop in order to extract a dark, gray and black heavy mineral which soils the fingers and marks paper. It occurs in but small quantity and seems to be a mixture of graphite with something else disseminated in the breccia; it is used by the natives as "kohl," and they call it of course súrma[2]. (I have not yet had time to examine it closely).

This is the first instance in which I have met with igneous rocks among any of the mesozoic or tertiary groups of the Punjab. The locality is fairly within the region of the Subáthu beds, and these trapps may be but an outlying portion of a larger igneous area to the westward towards Khost,[3] in which direction, as well as up the course of the Kurram as far as can be seen, the mountains present a softness of outline and a generally bare or withered-grass-covered aspect, entirely unlike that of the hills around on any other side.

Chaperoned by a couple of tame armed Waziris, in addition to the guard, I visited the scarped outcrop of their hills south of Thal. On the way thither, a low ridge between the Singroba and Shakkalli streams was found to consist

[1] Much used by the *Yagi* tribes for gun flints.

[2] This is perhaps the mineral mentioned as antimony occurring at Punjali-i-Shah Kurram river, by Agha Abbas, in Jour. As. Soc. Bengal, vol. XII, p. 595.

[3] I have seen specimens of asbestus from two miles west of Segai Kángah Khost, where it is so plentiful the people are said to make it into ropes; the locality is stated to be two long days' journey from Thal into Afghanistan.

of the same kind of hard, dark-weathered sandstones and olive and purple shales as occur between Thal and Kadimuk. The beds are vertical and folded, striking nearly N. N. E., and some of the sandstone bands contain badly preserved shells of large oysters, others those of a long and narrow but smaller form. South of the Shakkalli river is a mass of greenish gray clay coasting round the escarpment, extending down the Kurram, and very probably the same zone as is seen at intervals eastward as far as Togh. Resting upon this clay with a southerly dip, there is a band of some 100 or 150 feet of dark and lighter-coloured, mostly thin-bedded, compact, Alveolina limestone, immediately succeeded by a thin layer of calcareous concretionary pseudo-conglomerate, over which come the usual bright red clays and gray sandstones of the Murree group, the latter here sometimes enclosing small pebbles. Climbing to the top of the scarp, these and similar beds are seen to undulate over the country towards Dallan. Southwards they form large horizontally stratified elevations, amongst which a scarped hill at a distance, the scarp doubtles formed by a somewhat bent and twisted zone of nummulitic limestone, is the western termination of the Ragotungi ridge of the Kohát salt field, where that ridge passes into Waziri land. Still further off to the south is the rugged outline of a high ridge in the upper Siwalik sandstone and conglomerate basin north of Banu.[1]

Near the edge of the scarp, not so much as 200 feet stratigraphically above the nummulitic *Alveolina* limestone, I found several fragments of large mammalian bones in a coarse pseudo-conglomeratic layer, but could find no teeth. One narrow bone, broken into three fragments, seemed to show the tubular structure of those belonging to birds. I have preserved the specimen, though a bad one.

This was all that I could ascertain of the local geology of Thal: the high mountains beyond the Kurram were too far off to form a close guess as to their composition. In the river and in the terrace above it, the travelled boulders and pebbles, loose or cemented into conglomerate, present a great variety of rocks, amongst which the only ones I could identify with those of the Indus deposits were a dark fine-grained syenitic gneiss and a well-known variety of white quartzite covered with conchoidal markings like gastropod sections, which occurs *in situ* among the Tanol rocks of Hazára. Others include varieties of gneiss, coarse and fine, micaceous schists, altered earthy and silicious rocks, red jasper, white and brown quartzite, purple quartzite, gray sandstone, gray and purple ferruginous limestone, dark hornblendic trap, white eurite, white semi-crystalline marble, red quartzite, many limestones, but none, that I observed, of slate. These may all be found hereafter on the flanks of the Sufed Koh.

Conclusion.—The route from Kushálgarh to Thal shows a considerable change in the upper nummulitic zone compared with its eastern sections as far as the river Jhelum. Near Murree this zone has an apparent thickness of some 6,000 feet, and is most largely composed of clays and sandstones frequently of red or reddish colours with subordinate bands of coarse fossiliferous (num-

[1] A nummulitic limestone patch in Waziri land, north of Banu, shown on the sketch map, Records, Vol. X, p. 107, has been a good deal misplaced to the westward of its real situation.

mulitic) sandstone, or of marly or pure limestone, and one prominent dark limestone band 700 feet thick.

In the Râwalpindi plateau the zone is greatly disturbed, has apparently a less thickness, up to 1,500 or 2,000 feet, and comprises a few alternations of highly fossiliferous, marly and other nummulitic limestones, with red, purple and olive clays, &c.

Gypsum and petroleum occur along this part of the zone, chiefly in the lower ground, the former in considerable quantity; gypsum also is met with in red rocks of somewhat Subáthu aspect, their relations obscured by disturbance, among the Mochipuri mountains north of Murree, at Dungagali, &c.

In Bangásh on the road to Thal and southwards, these Subáthu eocene rocks occupy a large area, one part of their section alone giving an estimated thickness of more than an English mile, to which large additions should be made for the total bulk of the group, not less perhaps than 7,000 or 8,000 feet. The limestones here occur in thick zones of from one to over 300 feet, becoming more numerous northwards in the Mirkhweli region, and largely made up of beds containing *Alveolina* almost exclusively. Interstratified with these are thicker zones of rocks exactly resembling Murree beds, but including also many bands of olive clay. The gypsum of the group appears here in the salt field, and on its borders, but much more largely developed than to the east.

It would seem that the zone is changing again to the westward, the limestones disappearing in a great measure, and a mass of unusually hard sandstones with marine fossils and very thick greenish or gray and some purple clays forming a prominent part of the group in the neighbourhood of Thal.

A possible break at the top of the Salt-range nummulitic limestone has been suggested by Mr. Medlicott,[1] partly from the occurrence of a band of limestone conglomerate at the base of the overlying series. The presence of this detrital rock is not accompanied by any visible stratigraphic discordance, and in the section on the flank of Kadimuk north of Thal, we have a band of limestone conglomerate interstratified with the local lower part of the Subáthu beds. This occurrence is perhaps worth noting in connexion with the supposed break, with the abnormal northern junction of this Subáthu zone and the hill limestones, with the appearance of a transition across this break at Clifton (Murree), and with the absence of any unquestionable representative of the Subáthu zone north of the line of abnormal junction, so far as is yet known, nearer than the distant deposits on the Upper Indus, if even there.

Nothing has been found in this country antagonistic to views I have previously expressed regarding the nummulitic rocks of the Punjab (Records, Vol. X, p. 109, etc.), particularly as to the position of the Subáthu eocene beds above the mass of the eocene hill limestones[2]. Still some approach to the eocene hill limestone character among these rocks has been observed in scarcity of fossils and darkness of colour. Perhaps no feature is more prominent in the structural geology of the Punjab than the liability of its rocks to horizontal (lateral) varia-

[1] Memoirs, Vol. III, Pt. 2, p. 91, and Records, Vol IX, p. 57.

[2] See note 2, p. 130.

tion in thickness and character,—an observation quite borne out by this western part of the upper nummulitic group.

The occurrence of igneous, possibly volcanic, rocks in the Subáthu zone at Thal, should any of them prove contemporaneous, and should they be largely developed to the west, may introduce an entirely new feature, complicating the relations of this Subáthu group to the neighbouring tertiary or older rocks of that part of Afghanistan.

It may be possible that some of the Mirkhweli Subáthu limestones extend into the Urakzai mountains, the strike of parts of these lying in the same general direction as that of the Bangásh hills; but near Hangu, where the latter most nearly approach the former, a sudden difference of both dip and strike between the two sets of rocks was suggestive of a fault; nor were the interstratified red rocks of the Mirkhweli sections seen anywhere in the much-exposed Urakzai escarpments. Further west at Thal and Darsamand, where spurs from the northern mountains were reached, indications of fracture dividing the Subáthu zone from limestones of secondary age were found in both cases.

Of the age of the rocks forming these northern mountains, it has only been possible to collect some evidence of the presence of mesozoic rocks. The great height and bulk of the mountains, as well as the conspicuous northerly inclinations of their strata, together with their being so largely composed of limestones, leave ample room for the occurrence of all the eocene and mesozoic groups of the northern Punjab ranges, and space to spare for palæozoic ones besides; but in none of the streams coming from them, did I observe any fragments or fossils proving the existence of palæozoic rocks among these mountains.

The very low horizon at which bones, presumably mammalian, were found south of Thal is not incompatible with the distribution of bone beds elsewhere in the Upper Punjab, these occurring even among the nummulitic rocks themselves. The circumstance may also be connected with the gradual disappearance in a southerly and westerly direction of nearly the whole of the great group of the lower tertiary mechanically formed beds, the absence of which is a marked feature in the westerly extension of the Salt Range, trans-Indus.

FURTHER NOTES ON THE GEOLOGY OF THE UPPER PUNJAB, *by* A. B. WYNNE, F.G.S., *Geological Survey of India.*

(*Supplementary to those in Records, Geological Survey, vol. X.*)

Description of the ground.—The rugged district of Hazára stretches far into the regions of the Western Himalaya between the rivers Indus and Kishenganga, and embraces the native hill states of Amb and Kaghán as well as the portion directly under British rule. Its mountains, being parts of the greater ranges, present a somewhat complex assemblage of lofty spurs, rather than distinctly individual chains.

The long glen of Kaghán curves to the eastward-by-north between great snowy ridges. Its stream is the Nainsúk, or Kunhar, river, which enters the

Jhelum below Muzaffarabad. Between the north-western watershed of the Kaghán valley and another great mountain spur from the northwards, the upper waters of the local river Sirun find their way southwards towards the Indus through the valley of Bogurmang. On the east of this valley is the lofty truncated peak called Músa-ka Masala (the praying carpet of Moses), 13,378′, situated in the border country of the hill-men nominally within our frontier; and on the west are high elevations called Palleja Behisht (Heaven) and Shaitán-ka-gali (the devil's neck or pass). Further west the Black mountains (scene of late frontier warfare) rise, on this side of the unknown, or at least unmapped, portion of the upper Indus channel.

One march westward of the lower Nainsúk, at a much greater elevation surrounded by still higher mountains, is the flat lake-like plain on the course of the river Sirun forming the detritus-filled valley of Pakli.

Between the Pakli valley and the Indus rises the mass of mountains in the state of Amb, culminating at Bahingra in a height of 8,608 feet above sea level.

A broad cluster of hills having elevations of four, five, and six thousand feet spreads from the Sirun to the valley of the Dore; and from near the junction of these two streams the most isolated ridge in the whole country, that of Gandgarh, trends in a south-westerly direction, rising to an elevation of 4,137 feet between the Hazára plain and the river Indus.

Again, occupying the southern side of the district is another, broader, lofty tract, presenting endless alternations of confluent ridge and valley, with a marked north-east south-west strike. This elevated tract rises from the Nainsúk torrent, near Ghari Habibula, and with altitudes of 8,000 and 9,000 feet overlooks that river and the Jhelum; then, passing between the stations of Murree and Abbottabad, it gradually becomes less elevated, though still presenting high summits and long south-westerly valleys, till it leaves the district as a part of the Márgalla range, near the grand trunk road from Ráwalpindi to Hasan Abdál.

The Indus valley is a deep defile amongst the mountains, where, coming from the north, the river first bounds this district, then passing Derband, Amb, and Sittána, its valley expands to a width of about two miles at Torbela, a few miles below which place it opens out upon the plains of Chuch and Yusufzai.

All over southern Hazára the more or less north-east south-west run of the valleys, streams, and ridges coincides generally with the strike of the rocks. In central Hazára, disturbance of the strike would appear to have produced a less regular structure of the ground as to depressions. In the Gandgarh range, this ridge is itself a strike-feature, and the mountain torrents cross the bedding of the rocks; while in northern Hazára, in Agror, Bogurmang and the lower part of the Kaghán valley, the northerly and north-westerly run of the rocks, resulting in many marked features of the ground, approximates more to the general Himalayan bearing eastward of the river Jhelum, than to the abruptly deflected south-westerly strike of the rocks westward of the same river.

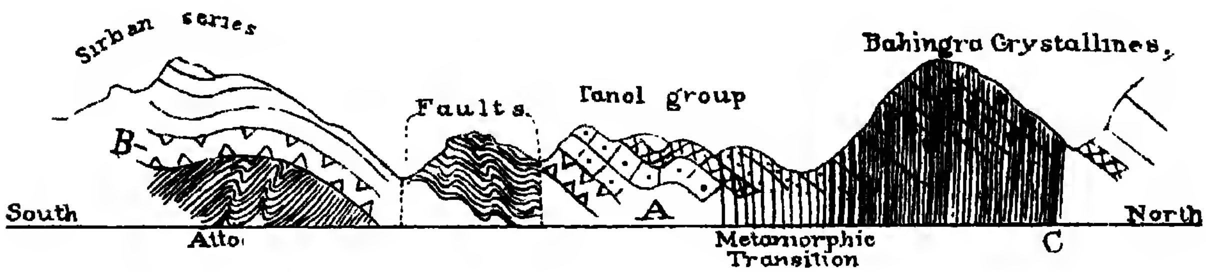
Geological structure.—I have already given some account of the outer Himalayan series in Hazára (Rec. Geol. Surv. Ind., vol. X, part 3); but now that it is to be noticed at more length, it will be well to subjoin a short tabular list of these Hazára groups, placed as far as possible in their natural order of stratigraphical succession as follows :—

	PLEISTOCENE	12	Northern detrital drift.
	PLEISTOCENE	11	Alluvium and river drift.
	PLEISTOCENE	10	Post-tertiary valley or lake deposits.
	?	9	Murree beds, sandstones and clays transitional with
	EOCENE	8	Upper nummulitic beds, limestones, sandstones, clays.
	EOCENE	7	Hill nummulitic limestone older than above.
MESOZOIC.	CRETACEOUS	6	Limestones chiefly.
MESOZOIC.	JURASSIC ...	5	Ditto, black shale (Spiti) and dark sandstones.
MESOZOIC.	TRIASSIC ...	4	Limestones, dolomites, breccias, shales, &c.
PROBABLY PALÆOZOIC.	?	3	Infra-triassic sandstones, breccias, &c. } ? same.
PROBABLY PALÆOZOIC.	?	2	Tanol series—Quartzites, sandstones, dolomites, &c. } ? same.
PROBABLY PALÆOZOIC.	(*Observe : 2 and 3*		*may possibly or probably be parts of one group.*)
PROBABLY PALÆOZOIC.	?	1	Attock slate series : Fine slates and grits, with limestone bands, sometimes largely developed.
PROBABLY PALÆOZOIC.		B	Intrusive traps, in Attock slates and Tanols also in metamorphic rocks.
PROBABLY PALÆOZOIC.	?	A	Hazára gneiss and the most crystalline altered beds.

A. Highly crystalline metamorphic and azoic rocks.—It will be observed that I have given these rocks a separate place at foot of the list, an arrangement which might be supposed to convey the idea that they were really the oldest part of the series ; and under ordinary circumstances it would appear easy to consider the granitoid gneiss as the fundamental portion of the whole. The observations made in the field have, however, shown indications of the presence of the singular Himalayan phenomenon of highly metamorphic rocks resting upon others possessing far less, or even in cases little or no, traces of having undergone metamorphism. Hence it is necessary to avoid hasty conclusions; for, if the stratigraphical superposition to be described really represents the normal sequence, the inference follows that among these metamorphic rocks a portion at least may be representative of palæozoic or even newer groups.

The unaltered rocks lie in the southern part of the district, the most altered in the northern region; but in passing from the former to the latter, neither a continuous, nor a simply interrupted or inverted, descending section is found. From the tertiary beds down to the slates, No. 1 (omitting No. 2 as doubtfully present), a descending series may be observed, with two breaks, the lowest of which is prominently marked. From these slates towards the Hazára gneiss, an ascending series, differing from that just mentioned, prevails; and in the gneiss region itself there are traces of interstratification apparent, the position and inclination of the bands being suggestive of these altered rocks occupying a high place in the northern series. The sequence could be accounted for if this northern series could be proved, by any unconformable contact, older and entirely different from the southern one; but at the point where operations had to be discontinued, it appeared to be gradually becoming evident that the great Tanol group of the northern series was passing laterally into the infra-triassic group of the southern and Sirban mountain sections (see Mem. Geol. Surv., vol. IX, part 3: Description of the Geology of Sirban). This would assert its position to be newer or higher than the Attock slates; while its upper beds pass by prevalence of metamorphism into the transformed, crystalline, northern rocks with a strong appearance of underlying a most intensely altered portion of these.

The observation may in a general way be made, that the metamorphism of the rocks of the northern part of the district exhibits a lateral or geographical rather than any development coinciding with antiquity of the strata. Inversion, apparent or obscure, is often made to explain the difficulty of such a case, but the employment of this supposition may have a limit; as in the present instance, where, if the Tanol and infra-trias groups should prove identical, or even in parallel superposition, physical impossibility would be involved.



A glance at the accompanying diagram will explain this: the lower portion of the Tanol group (A) is very similar to the general aspect of the infra-triassic group (B), and as I have observed, they seem to unite in the Tandiáni mountains, eastward of Abbottabad. But the infra-triassic group (B) rests unconformably upon the Attock slates, and its basal bed is a conglomerate largely made up of fragments of this slate series. Consequently the presumption is that the Tanol group is newer than the Attock slates, and not part of an inverted series, the oldest portion of which would be represented by the metamorphic rocks.

It is unfortunate that, however closely the groups A and B in the above diagram may be united, the succession upon the northern side of the crystalline area (C) is unlikely to become known, owing to inaccessibility of the country; otherwise, its comparison with the southern extra-metamorphic series would be in all probability instructive.

In the Pír Panjál region, not very remote from Hazára, an opportunity has occurred of studying the relations of both sides of a chain, the core of which is also formed of gneiss similar to, if not identical with, that of Hazára; and Mr. Lydekker, to whose research we are indebted for the information, is of opinion that a clear case of inversion is there established, and the series on each side of the crystalline axis is the same (Rec. Geol. Surv. Ind., vol. XI, p. 30). Comparing that region with this, we should find little possibility of identifying the flanking series, although this Pír Panjál chain, between Kashmir and the Punjáb, presents an assemblage of rocks continuous with those of the Kájnág range, north of the Vedusta, or upper Jhelum, and doubtless continuous in a general way with the series of upper Hazára, perhaps, however, beyond the limits occupied by the Tanol and immediately associated type of rocks.

The Pír Panjál chain, with its gneiss and slates, &c., is considered as belonging to the Central Himalayan System (Annl. Rept. Rec. Geol. Surv.

Ind., 1878); its gneiss is recognised as re-appearing in the Kájnág range (Lydekker, *l. c.*), and I can answer for the lithological identity between that of Hazára and the transported masses of the Kájnág gneiss scattered along the Vedusta valley on the Murree route into Kashmir. Still I am quite unable to identify the other members of the Hazára series, generally or in detail, with those rocks which Mr. Lydekker has found displayed along the Pír Panjál range. To show the contrast, I propose, after describing the local series here, to place it and that of the country to the east (as recorded) in parallel columns.

The Hazára gneiss—is a completely crystalline granitoid rock, of whitish gray colour, composed of quartz, felspar, and black mica (biotite), white mica (muscovite) being often present as an accessory; and the rock is rendered porphyritic by an abundance of large twin crystals of pinkish or flesh-coloured orthoclase measuring from two to eight inches in height, more commonly from three to four inches being the longest dimensions. These lie in all directions in the matrix, sometimes affecting a linear arrangement, which may mark the former lines of now obliterated stratification. Schorl is locally present, and garnets are occasionally seen, both as rather unfrequent accessories. Separate bands or veins of rock crystal or opaque quartz are rare, but dykes of easily decomposing trap, apparently greenstone, are not unusual.

I have often sought near the junction of the crystalline rock with the adjacent schists for evidence as to its being intrusive or otherwise; and in some directions I have found what appeared to be distinct dykes or veins among the schistose rocks; but contrasting with these, and sometimes in contiguous localities, the schists exhibited a gradual transition towards the main granitoid mass by reason of great intensity of metamorphism, the region of actual contact being, however, defined within rather narrow limits.

For instance, on the southern ascent of the Susul Gali pass into Agror, I found masses of the adjoining schists included in the crystalline gneiss, presenting many gradations of alteration; and although the stratification was still discernable, parts were as crystalline as the adjacent gneiss, enclosing the same large felspar crystals, and other parts had assumed the form of a gneiss of much finer grain than that of the main mass.

In other cases, as near Mánsahra, detached masses of the schistose rocks were found entangled and enveloped amidst the gneiss without exhibiting this extreme amount of alteration, not being indeed more altered than the rest of the adjacent schistose beds. The country generally is one in which a wide or distant view often shows more of the broad structural relations than is gathered from close inspection of details; whilst in places, nothing is open to immediate view except small features, the continuity of which cannot be observed or relied upon, yet the facts concerning which must take their own place in forming conclusions. Thus, with regard to the gneiss, few traces of stratification are to be found in minute detail, though the outline of one of its principal masses, the Bahingra mountain, presents the normal Himalayan feature (common among the stratified groups) of a steep outcrop slope towards the plains, and a long gentle declivity towards the mountains of the interior. Coinciding with this form, and lying as if in alternately bedded masses, are groups of well stratified quartzites and schists, sometimes cropping out along the whole of one side of a spur the opposite slope of which presents a sheet of the gneiss for many miles.

The whole aspect of the gneissic or granitoid region, so far as visited, gives the impression that an extensive series of mechanically formed detrital rocks has undergone transformation, the metamorphism being locally intense, and its extreme results expressed by a very abrupt transition from highly altered schists into gneiss itself.

Less highly altered azoic rocks.—The schists and quartzites adjacent to the gneissic area are, as a general rule, distinctly stratified; and, no matter in what direction inclined, they almost invariably dip towards exposures of the gneiss. They present the somewhat peculiar feature that they occupy, so far as yet traced, the deepest valleys, such as those of the Nainsúk, Sirun, and Indus; this feature, together with their dip, intensifying the appearance which they present of underlying the gneiss.

The metamorphism of these rocks bears a more or less constant relation of place to the margin of the gneissic tract, though it possesses no definite outer boundary. It appears on the left (Hazára) bank of the Indus to travel across the stratification of beds that are less altered further away upon the same strike, as though it were an effect related to the presence of the gneiss among the Buneyr hills in the wild tract beyond that river; or it might be perhaps inferred that the altered rocks here, lying lower than some in the neighbouring country, indicates the presence of plutonic ones at a depth beneath this region no greater than the distance within which the rocks at the surface nearest to the gneiss have been most metamorphosed.

The altered rocks in this situation consist chiefly of various talcose or micaceous schists, sometimes slaty, sometimes even conglomeratic from the presence of white quartz or quartzite pebbles; they are rarely calcareous, but sometimes contain bands of compact and rusty-looking dolomite or magnesian limestone.

B. Intrusive traps.—In both the more and the less crystalline metamorphic groups (as well as in the Tanol series), igneous rocks are not uncommonly met with as dykes or intrusions. One of these near the border of the Amb country, south of the Bahingra mountains, is of considerable size. Generally speaking, these rocks are of a dark, dense, variously crystalline greenstone, seldom porphyritic and never amygdaloidal. They do not present recognisable signs of having partaken of the metamorphism of the associated beds, but they are frequently weathered to an extreme degree, this condition perhaps having some connexion with their position.

1.—*Attock slates: (Azoic).*—The general appearance of this group has been already more than once described. It consists of various dark, olive, black or brownish fine earthy slates, sometimes with purple bands and occasionally interstratified with greenish fine-grained sandstones. Bands of compact, waved, pale and dark gray or rusty-brownish limestone are locally numerous; though comparatively rare in some localities, in others, as in the Gandgarh range, they assume an enormous development.

Here too these limestones include among their upper layers a band or bands of compact white or greenish semi-translucent waxy-looking thin-bedded marble, associated with certain coal black graphitic shales, one or two very constant zones of which are known to the natives as the "*Súrma lurri*" *rug* or belt. Dolomitic and brecciated, or pseudo-brecciated, varieties of the limestones are frequently met with (see Section 1).

Geographically the slates intervene between the mesozoic limestones of the southern Hazára hills and the Tanol group of the northern series. An isolated patch of them and their associated limestones stretches from the Nainsúk valley, forming the lofty peak of Mián-Jáni-ka-Chauki, and passing westwards by Sujkot among the limestone hills south of the Dore valley. Their stratification is much disturbed; cleavage is prevalent in places along so many planes that the rock is cut up into splinters; in others it is scarcely developed, and the thinly laminated structure of the slates enables them to be split into flags or even bedding slates, of inferior quality.

A long fault forms their southern boundary for a considerable distance, another brings them in contact with the northern side of the Sirban mesozoic exposure, and still another forms their northern limit for many miles, coinciding with a long valley running from Haripur towards the north-east, so that this fault passes northwards of Abbottabad.

The unconformable infraposition of these slates to the infra-triassic rocks of Sirban has been pointed out in the paper on that mountain (*l. c.*); their junction with the Tanol group is mainly a line of dislocation; but where this is not evident, they appear to underlie those rocks; and they are seen unconformable to, and apparently beneath, beds similar both to some of those in the Tanol group and to the Sirban infra-triassic beds, on the road from Abbottabad to Mangli (or Mangal); they also unconformably underlie the *Dicerocardium* limestone of the Zyárat hill close to Hassan Abdál.

The main strike of the slates, and their most extensively recognisable fault lines, follow the north-east south-west bearings of the rocks and ranges west of the river Jhelum with varying regularity. They possess an almost monotonous unity of aspect which imparts itself to the ground they form, this everywhere presenting the same minutely mammilated and steeply fretted surfaces, coated with a scaly layer of finely divided detrital fragments, giving the ground a peculiar soft greenish-olive tint. It is only when limestone bands are present that the outlines become rugged.

As a rule, in the southern part of Hazára, the slates are unaltered along the side of their exposure next to the mesozoic and eocene limestone hills; but on the opposite side, between Gandgarh ridge and the Indus, as well as generally towards the Tanol group, some amount of metamorphism has rendered them silky or lustrous, and traces of alteration are much more evident in their associated limestones which often present a curiously matted foliation.

Conglomerates, properly speaking, have not been found in the Attock slate group; but a few of the more coarse-grained beds were observed to enclose lumps of quartz or quartzite scattered through the rock, and not unfrequently presenting pebble-like forms.

These Attock slates of Hazára have been found, as usual in their more westerly extension, to contain no vestige of organic life. Even the limestones associated with them, and evidently belonging to the series, though in some places having a pseudo-fossiliferous appearance, seem wholly destitute of any organic remains discoverable by the naked eye or the pocket lens.

But in the southern portion of these rocks, along the margin of the mesozoic limestones, there are limestone bands included among the slates in which I have in two or three instances found fossils. At one spot near the road from Khánpur to Haripur (between Padni and the road) I found highly disturbed or vertical limestones containing the well marked sections of *Dicerocardia*, &c., and again in a limestone ridge little more than half a mile due west of Bandi Atáhi (called by the people of the locality Bandi Tai Khán), and east-south-east of Huveliyan on the Dore, I found imperfect and fragmentary casts of crushed *Ammonites.*

Although there are in the vicinity of these fossil-bearing limestones others of the hard, frilled, and peculiar aspect of those found in the slate series, I am by no means prepared to say that these beds with the fossils belong to that series; I regard them as more probably belonging to the adjacent mesozoic series, let into their present position by dislocation, and subsequently so wedged among the slates as to make it appear that the present is their original situation. My reasons for this conclusion are shortly, that the *Dicerocardium* limestones of Hasan Abdál and Sirban are evidently unconformably superior to the slates, and that the rib of limestone with *Ammonites* is almost continuously traceable into the mass of mesozoic and eocene limestone hills crossed by the upper road from Murree to Abbottabad.

For some time past these Attock slates have been provisionally considered of silurian age, from the recorded discovery by Dr. Falconer of "lower silurian fossils" in the Kábul river of the Pesháwar valley (in slaty rocks ?) derived from the Khyber hills on the same general strike. Their silurian age was accepted by Dr. Verchere, and adopted by Dr. Waagen and the Geological Survey; but it has never appeared that the correlation was quite correct, nor have I been able to trace any thing stronger than indirect allusions to Dr. Falconer's discovery; such as Major Godwin-Austen's reference in his paper on Kashmir (Quar. Jour. Geol. Soc., Lond., Vol. XXII, p. 29), where he says, "As lower silurian fossils from the Khyber hills were found by Dr. Falconer in the gravel of the Kabul river, as also by Colonel Strachey on the Niti Pass, the great masses of slaty and metamorphic rocks which in this part of the Himalayan chain underlie the carboniferous beds may be referred to a lower palæozoic series." Major Vicary mentions a few of the genera found by Dr. Falconer above referred to (Proc. Geol. Soc., Lond., Vol. VII, p. 45), but it does not appear that the whole or most of these are strictly silurian forms. Still the impression conveyed is too definite to have been founded on a mere guess. Nor does it after all appear that the identity of the Attock slate group and the Khyber beds is at all fixed, though very similar slaty beds are said to occur beyond the Khyber pass towards Jelálábád. Hence the age of these slates can hardly be considered established with sufficient accuracy to warrant their being regarded definitely as silurian, while the probability is that they are palæozoic. (See Manual, p. 500.)

2. *Tanol group: (Azoic)*.—Lying between the Attock slate region and the metamorphic area is a great group of rocks, the existence of which was unknown until the past season, and the analogues of which I am unable to discover among the recorded sections of Kashmir and the Pír Panjál. I have called these rocks for sake of distinction the "Tanôl" group, from the ancient name of the country they occupy.

These beds are always associated with the schists of the northern series, and they appear to pass both into and underneath a considerable section of these schistose rocks. They comprise an enormous thickness of gray or drab quartzose or quartzite rocks, in rapid alternation with dark earthy bands, flaggy, shaly or slightly schistose. Many of the dark intervening bands remote from the gneiss are in appearance scarcely altered, and have much the look of Indian jurassic plant beds. Others of the alternating layers are exceedingly fine, unctuous, slaty argillite, sometimes associated with conglomeratic slates, the pebbles of which, ranging up to the size of goose eggs, are usually formed of white quartz or quartzite.

The quarzites or quartz rocks frequently show lines of oblique lamination, or other lines of deposition; and they include amongst them beds of almost unchanged sandstone, the weathered surfaces of which have the small warty protuberances such as are frequently observed upon certain mesozoic sandstones in the peninsular Indian area.

Some of these Tanol rocks, towards the apparently upper part of the group, are of a clear grayish white color, soft enough to mark the fingers when handled, and with these the slaty rocks of paler color prevail. The soft white rock is not calcareous, nor has it a strongly argillaceous appearance; reduced to fine powder it is but slightly soluble in acids, even when boiled for a considerable time: it fuses on thin edges to a white glass, and in powder on charcoal to a somewhat coherent semi-fused mass, giving no alumina reaction with nitrate of cobalt, nor any distinct magnesia color. This powder fuses with effervescence in carbonate of soda, but is not quite fusible in borax. The color of the bead given with reagents was not definite enough to form an opinion by. The specific gravity of the pieces examined was about 2·78. These soft white beds, though retaining a good deal of their detrital aspect, have undergone so much metamorphism that it is uncertain what kind of sandstones they originally were; and yet the strata amongst which they are intercalated do not seem to have suffered extreme alteration.

Occupying synclinal folds, or else occurring at various horizons, in the Tanol group are thick zones of variously colored pseudo-brecciated, silicious, cherty or compact gray, black, and buff dolomitic limestone, with which are occasionally associated intensely black graphitic and sulphurous shales, or else purple and red sandstones and slaty bands.

The Tanol group extends from near Mangli (and probably further east among the Tandiání mountains) by Sherwán towards the Indus, passing north of the Gandgarh range. Its relations to the Attock slates on which it seems to rest are obscure, the junction being frequently either a line of dislocation or concealed by quartzose debris; but still the disposition of the two groups in the neighbourhood of the lower Sirun and Dore rivers is one consistent with unconformity.

Trap rocks, chiefly intrusive and perhaps intrusively interbedded, are found in the group, mostly among the more metamorphosed portions, and of similar dense crystalline basic kinds to those of the altered rocks.

I have not been able to detect any organic remains among those Tanol rocks.

The apparent superposition and probable unconformity of the Tanol upon the Attock slate group, and the presence of silicious dolomites and red sandstones in the lower part of the former, as well as in the lower part of the infra-Trias of Sirban mountain, are points of resemblance which would indicate a connexion between these infra-triassic beds and the Tanols; but the latter exhibit a thickness enormously greater than that of the group overlying the slates in Sirban, nor has the distinct evidence of conglomerate formed of slate debris been found at the base of the Tanol group, neither have any fossiliferous limestones or other beds identifiable with the Sirban Trias been met with. Notwithstanding this, on tracing the Tanol group and the Sirban beds to the north-east, they seem to unite in one great series in the lofty mountains near Tandiání, sweeping over an anticlinal axis near the camping stage of Mangli or Manghal. The decision of this important point must be reserved until the Tandiání hills can be examined.

The thickness of the Tanol group exposed in the sections from the Miánkháki stream northwards can scarcely be less than 20,000 feet, up to the place where they pass into the metamorphic rocks. Possibly some part of this thickness may be repeated ; in so disturbed a region it is difficult to say repetition does not occur, but general appearances are against it. Nor is it easy to account for the absence of the mesozoic series of the southern hills unless they may possibly be partly represented by some of the dolomitic zones, or else metamorphosed beyond recognition. (See Section No. 4).

Far away to the north, in the Palleja heights, overhanging Bogurmang, I could see among the snows a basin-like arrangement of strongly bedded rocks as though resting unconformably upon the metamorphics. Of these the only specimen I could obtain was one of a dark dense limestone. Should limestones prevail, and the sharply scarped form of the cliffs looked as if this were likely, the mesozoic series may in part be represented there, or perhaps some of the Kashmir carboniferous or other groups.

The Southern Hazára Series.—Of the rocks in this part of the district more was already known than of those to the north. The limestones of the hilly tract between the Attock slates and the Ráwalpindi upland or the Murree hills, present an extremely confused, contorted and faulted assemblage of mesozoic and eocene strata, an epitome of which is afforded by the instructive sections of Sirban mountain described in the memoir already quoted. The main features of the whole tract are, a large development of the triassic and of the great hill-nummulitic limestones, the disappearance westward of the jurassic (Spiti) shales, and their place being taken by limestones containing *Trigoniæ*, amongst which *T. ventricosa* is a prominent form, together with some poor and fragmentary *Ammonites*, *Belemnites*, *Gryphæa*, and small brachiopods; also the disappearance of the infra-Trias group of Sirban, which is at least no longer recognisable to the westward, nor has the cretaceous band there observed been found reappearing with the same character, if at all elsewhere in this district.

For fuller detail I refer the reader to the already described Sirban sections (Mem. Geol. Surv. Ind., vol. IX, Art 3, p. 331); but to convey a general idea here, I abstract the table of succession given in that paper at p. 2, *viz.*—

6. NUMMULITIC.—Thick limestones with some shales, fossils in places.
5. CRETACEOUS.—Thin-bedded limestones without fossils apparently.
Impure ferruginous sandy limestone, weathering rusty—fossils.
4. JURASSIC.—Black Spiti shales.

Unconformity.

3. TRIASSIC.—Thin-bedded limestone and slaty shales, dolomite, limestone; fossiliferous (*Megalodon* and other) beds.
2. BELOW THE TRIAS.—[Infra-Trias] Hæmatite, dolomite, quartzite, sandstones and breccia.

Marked Unconformity.

1. PALÆOZOIC ?.—Attock slate.

Of these groups the Attock slates, ascertained from larger developments to be the same group exposed at Attock, have been already described.

The infra-Trias, however, requires a few words of description in order to enable a comparison to be formed between it and the Tanol group. It seemed to show a triple sub-division, the lower one consisting chiefly of red sandstones, red shales, and red quartzitic dolomites, underlying another zone of dolomites of lighter color often highly silicious and of very considerable thickness. These words would apply almost equally to those well marked red and lighter colored dolomitic zones of the lower, but not lowest, part of the Tanol group. The sections given in the Sirban memoir may be compared with that crossing the Tanol group, No. 4, appended to this paper.

The third sub-division, composed of hæmatitic rocks, quartz breccias, sandstones and shales, seems less capable of recognition to the north; but it might be there subordinate either from lateral change or blending with the dolomitic zones.

4. *Triassic.*—In this group the further examination of Hazára has revealed the existence of a great development of limestones with some shales. Many of the former show features characteristic of the Sirban exposure, yet are most frequently without the arrangement into more or less defined, though sometimes obscurely, fossiliferous zones. Owing to this local character the exact lines of the Sirban section have not been traceable amid the larger and thicker exposures elsewhere. Although the most characteristic feature,—the presence of numbers of impacted *Dicerocardia*, sometimes accompanied by shells of the *Megalodon*, visible in section only,—has been observed in one or two localities; the point of itself is insufficient to establish actual identity of these fossiliferous beds, but decisive as to the general age. Outlines of these fossils from the Sirban rocks are figured at page 8 (338) of the Sirban paper, *l. c.*

Other fossils among the triassic beds generally are so few, so fragmentary, and so rarely met with, that it is often doubtful whether the beds are really triassic or jurassic, nothing being left for guidance but the not very definite point of lithological character.

The thickness of these rocks in the neighbourhood of Khánpur, however difficult to fix on account of plications, can scarcely be estimated at less than 3,000 or 4,000 feet, perhaps more than double the amount of the triassic series of Sirban, where the best exposed sections show the formation sheeting the northern side of the mountain, with inclinations of less than 35°, over a slope a mile and a half long with a rise of 2,000 feet. This being taken as the basis of calculation affords the inference that the Sirban trias formation may have a total thickness of between 1,500 and 2,000 feet.

The distribution of the formation as far as traced is shown upon the sketch map annexed; it seems to have suffered extensive inversion near Bagnotar on the Murree and Abbottabad road.

5. *Jurassic.*—The jurassic rocks of the southern region of Hazára are very subordinate, as to extent or thickness, to the underlying group. They are, however, traceable by numerous complicated exposures among the disturbances so prevalent in these hills. They appear amongst masses of nummulitic beds, at Shah Kabul summit, in the Khánpur country, as a rusty group of earthy limestone, shales of dark and light color, and occasional sandstone bands, identified by Dr. Stoliczka as similar to his Gieumal sandstone of other Himalayan regions. Similar rocks reappear near Garm Thun; and they are met again, though scarcely ever with exactly the same character, edging the southern frontage of the Márgalla range, and in the interior of the mass of hills crossed by the old bridle track from Murree, *viâ* Mári, to Abbottabad.

In the higher hills the jurassic formation includes in places a well-developed zone or zones of black Spiti shale, containing fossils characteristic of that group in Spiti, but both these shales and their fossils appear to be entirely wanting to the west, where a band almost made up of ill-preserved *Trigonia ventricosa* (not found in the higher hills) appears towards Shaladitta, associated with layers containing *Ammonites, Gryphæa, aud Belemnites.* But it is not clear whether these fossiliferous beds to the west are newer or older than the Spiti shales,[1] the groups never having been found in contact or in the same section; and the relation in both cases to the succeeding eocene rocks, so far as can be made out, being that of conformity.

The whole formation seldom exceeds a few hundred feet at most; but where its lowest limits may be, among limestone masses, part of which are at least triassic, though the upper portion may be newer, it is impossible to say without better palæontological evidence than is available, and without the reappearance of the Sirban discordance.

6. *Cretaceous.*—The few beds referred by Dr. Waagen from their fossils to this formation at Sirban are the only established case of its occurrence among these hills. In many places, however, there intervenes between the known

[1] These western fossiliferous jurassic rocks are stated in the lately published Manual of the Geology of India, p. 503, to "appear to be a continuation of the Gieumal sandstone." So far as I am aware, there are no sufficient grounds for the assertion as yet discovered.

jurassic and the nummulite-bearing limestones, a mass of light or dark-colored limestones without fossils, which perhaps belongs to the cretaceous period.

The fragmentary *Ammonites* found in a limestone rib southward of Huveliyan (see *ante* p. 121) on the opposite side of the Dore valley from the cretaceous band of Sirban, occurred in limestones with somewhat the aspect of those of the cretaceous zone; but it is not even known whether the specimens can be determined.

7. *Nummulitic.*—The nummulitic eocene limestones of these hills presents no peculiarity beyond the general features described in former papers (Rec. Geol. Surv. Ind., vol. VI, pt. 3, vol. VII, pt. 2, vol. X, pt. 3 ; Q. Jnl. Geol. Soc., London, vol. XXX, p. 61, vol. XXXIV, p. 347).

It occurs very extensively, yet its thickness, which must be very great, is difficult to determine on account of the frequent faults and the disturbance of the beds. One section from Murree northwards would indicate a greater thickness than 2,700 feet for what is but a part of the series; and from 3,000 to 5,000 feet may be a probable, though necessarily a very conjectural, estimate for the whole.

These dark gray eocene limestones of the outer Himalayan region, alternating frequently in some places with olive shales which are almost entirely absent in others, and containing sometimes an abundance of small Foraminifera, sometimes scarcely a fossil distinguishable with a lens, are in a manner peculiar to the northern regions of the Punjab, as has been already pointed out (*l. c.*, above). There seems to be a possibility that in the higher portion of the hills, traversed by the upper Abbottabad and Murree road, the group includes in its lower part dark red and blackish gypseous shales and sandstones of the aspect of those found in the base of the succeeding tertiary sandstone series, but the point is obscure. There is also a considerable appearance of transition from the upper or outermost beds of the Hazára hill-nummulitic rocks into the upper nummulitic zone near Murree, which is transitional with the lower tertiary sandstones and clays just mentioned. The apparent passage is deducible from the arrangement of the rocks in the region of the abnormal contact between the Hill limestones and outer tertiary zone, and therefore less trustworthy than it might be; still such appearances, even in disturbed localities, should not be overlooked (see Section No. 5 annexed).

The upper nummulitic beds of this district, scarcely appear within the hilly tract from Mochpura mountains westward in other than doubtful exposures. Some of its beds are faulted into junction with the hill-nummulitic and jurassic rocks between Shaladitta and Garm Thun, on the road from Ráwalpindi to Khánpur; and the faulted mass of red rocks with gypsum, in the Haro Kas below Dungagali (north of Murree), may either belong to this group or be intercalated, as just now mentioned, at a much lower position with the eocene limestones.

Another more extensive exposure of red argillaceous and arenaceous rocks was met with this season capping the Lachikhun mountain, in the range overlooking the Nainsük at Ghari Habibula from the east. Lithologically these might represent a variety of the lower tertiary sandstones (Murree beds), but have a harder, more slaty and more prominently red aspect. They are intersected by numerous parallel veins of white carbonate of lime, which is one of the characteristic appearances of the Murree beds near their disturbed junction with the hill rocks. There are, however, no such masses of nummulitic and mesozoic limestones associated with these beds as occur further to the south-west. Dolomites, limestones, and black carbonaceous or graphitic shales appear immediately beneath them; but these beds have much more the aspect of the infra-trias or Tanol rocks than of the newer limestones, &c., and none of them contain fossils so far as could be discovered. On one spur of the mountain near Kulis village, a situation which would indicate an inferior position to the red beds, I observed numerous shaken angular blocks of limestone containing *Nummulites*. These, although they could not be pronounced *in situ*, did not appear to have been far removed from their original place, and they would indicate an extension in this direction of the Hazára eocene formation.

The whole of the red series and associated beds on this range appear to rest unconformably upon the metamorphic schists, of which the lower half of the mountain mass is entirely composed; but no clean sections could be observed, and snow concealed much of the higher ground.

A small vein of galena among the schists in the Kakal ravine, not far from Kulis, is only worth mentioning to state that the quantity is so very small as to be ecónomically worthless, so far as this one vein is concerned, and unless others of much larger proportions are concealed in the vicinity. On examination at Calcutta specimens of the ore were found to be argentiferous, as is very commonly the case.

Before noticing the more superficial and less important deposits, it may be useful to glance at the comparative aspect of the two great series of rocks—those of the Himalayan system in Kashmír and those of the Hazára region, still further west. In order to present the state of the case as definitely as possible, I have taken the Kashmir series from Mr. Lydekker's papers, and placed it side by side with that of Hazára in a tabular form (annexed).

Commencing with the older rocks, it will be observed from what I have already stated, that the first discrepancy to be met with is in the position of the gneiss of the two regions. Mr. Lydekker refers to two kinds of Himalayan gneiss, but considers that occupying all or most of the gneiss areas on his map as of one kind, except perhaps the central portion of the Zánskár range, (not marked on his map, (Records, Vol. XI, p. 30) but forming the north-west south-east watershed north-east of and above Darwas). This great expanse of identical gneiss, presenting the same relation of conformity and transition into the overlying silurian schists, is of course newer than the "central gneiss" of pre-silurian age. The Kájnág ridge belongs to the Pír Panjál range, and its gneiss is at least lithologically identical with that of Hazára. But, though in the Pír Panjál this gneiss forms so well marked a base to the stratigraphic system of a widely-extended area, and the apparent alternation of the gneiss with quartzites and schists in Hazára affords a further point of similarity, its general situation with regard to the rest of the Hazára series conveys no appearance of its being a fundamental rock or the basal member of the stratified series.

Comparative Table of the Kashmir and Hazara Series on different sides of the Jhelum Valley synclinial or deflection of the Himalayan strike.

(So far as at present known).

Era	Period	Hazara Series.	Kashmir Series.		Remarks
Cainozoic	Pleistocene	Northern detrital drift ...		Alluvium.	
		Alluvium and river deposits ...		Karewahs ...	Probably equivalent to the post tertiary of Hazara.
		Post tertiary valley or lake deposits.	Siwalik ...	Upper. Lower—Nahan.	
	?	Murree beds.	Sirmur ...	Kasauli, Dagshai	These groups may be equivalent to the Murree beds.
	Eocene	Upper Nummulitic beds ...		Sabathu ...	These beds are identical in both regions.
		Hill Nummulitic limestones ...		....	3,000 to 5,000 feet of limestones absent in Kashmir.
Mesozoic	Cretaceous ...	Cretaceous limestones ...		....	Unknown in Kashmir as yet.
	Jurassic ...	Jurassic limestones, &c. ...		....	Unrecorded as yet in Kashmir.
		(Unconformity at Sir Ban).			
	Triassic ...	Triassic limestones, &c. Upper	Trias ...	Upper ...	The upper beds may be those of Sir Ban in Hazára.
		Triassic limestones, &c. Lower		Lower ...	From description in both regions not unlike.
Palæozoic	?	Infra-triassic sandstones, breccias, &c., and Tanol series, Quartzites, &c., metamorphosed northwards, and passing into gneiss and crystalline rocks.	Carboniferous	Including Kiol Krol and great limestone.	The Kiol series only seems to present any similarity to the Tanol group.
		Unconformity.			
	?	Attock slates, partly altered ...	Silurian ...	Pangi slates, Panjal rocks	The Attock slates contain limestones the silurian of Kashmir does not, but the Pangi slates to S. E. do.
		Intrusive traps.			
		The Hazára gneiss is identical with some of that in Kashmir, but differently placed.	Gneiss ...	Gneiss ...	The gneiss is difficult to recognise as the same in both regions, though partly lithologically identical.

The two unconformities in the Hazára series are unrecorded in Kashmir or Jamú.

Mr. Lydekker has specially pointed out the conformity of this Himalayan gneiss to the overlying silurian strata, but in Hazára, whether the contact rocks may be correlated with his Pír Panjál and Pángi groups or not, the manner of their junction as described above (see section No. 4), the enclosure of detached altered, and more highly converted metamorphic schists, within the gneiss, also the occurrence of dyke-like veins of gneiss amongst the schists, would show, that however conformable the original rocks may have been, this relation is rendered more than obscure by the intensity of the metamorphism they have undergone.

Thus, though the gneiss of the two regions may be identical in hand specimens, its diversity of arrangement in the two districts would point either to the occurrence of two different gneiss formations, or else, what is perhaps more probable, to the occurrence of two distinct modes or degrees of metamorphism affecting the rocks within its range differently in each case, coinciding with the stratification in one case, crossing it in the other.

The next point of dissimilarity in the features of these two regions is in connexion with the rocks resting immediately upon the gneiss. In Hazára there are no particular zones having this relation as yet explored; still the schists, &c., of Lachikhun mountain would seem to be a continuous portion of those of northern Kashmir, and may yet be found more palpably resting upon extensions of the Hazára gneiss than has hitherto appeared.

The more than 2,000 feet of blue and black slates, and flaggy slates with blue and fawn-colored sandstones, splintery grayish shales and locally abundant limestones of the Pángi series, scarcely find a counterpart in the Attock slates, though the general description more nearly resembles these than any other portion of the Hazára groups. But the Attock slates have never been observed passing downwards conformably and with intercalation into metamorphic rocks with alternations of gneiss: nor have they been known to contain erratic (*i.e.* travelled) fragments of angular and waterworn gneiss. Hence the Attock slates do not seem to represent the silurian of the Kashmir sections; or if, notwithstanding, they are a modified extension of that silurian formation, they differ in not being conformably associated with the gneiss.

The Panjál series—of black and green slates, sandstones, amygdaloidal rocks, brown sandstone conglomerates containing pebbles of quartzite and slate, white quartzites and sandstones, and below all black slates with pebbles of gneiss and quartzite, granitoid gneiss with bands of slate and quartzite,—seems also to have no closely similar group among the Hazára rocks. The gneiss with bands of slate and quartzite has indeed a certain resemblance to the association of the gneiss and schists of this country, and conglomeratic beds are not unknown among the metamorphic schists; but the whole aspect of the group, despite the entire absence here of the amygdaloidal beds, would seem to possess a rough similarity to the Tanol group, were it not that the latter contains limestones and dolomites, unrecorded in the Panjál series, and it has not the relation of conformable and transitional superposition upon the gneiss. Another difficulty is met with in seeking for the analogues of the Kashmir carboniferous beds in Hazára. The general diversity of the sections in these two adjoining areas prepares one for a difference here also, and I am unable to point to any Hazára group which would occupy the place of these rocks to the eastward, or which resembles closely any carboniferous exposure in Kashmir, as described by others or seen there by myself.

Mr. Lydekker suggests that local differences in the carboniferous sections of that country may be accounted for by supposing separate areas of deposition. If the differences increase towards Hazára, it would be rash to say the formation is as wholly unrepresented as it appears to be; but I have never found a trace of any of the fossils of this group such as I have met with both in the Salt Range and in Kashmir regions. One unfossiliferous limestone formation may so closely resemble another, that I cannot say whether the massive limestone formation of Gandgarh may not present some identity with that of the Krol group, which I have never seen, but which has been classed with the carboniferous beds of Kashmir, nor yet whether it is similar to the great limestone of the Jamú inliers. The slates of Hazára certainly have a less shaly look than those of the carboniferous group in the Lídar valley-Kashmir.

The occurrence of quartzites, black shales (graphitic or carbonaceous) with nodules of iron ore, and limestones in both the Kiol and the Tanol groups might indicate some identity, but though dolomites are more characteristic of both the latter series and of the infra-triassic of Hazára, and are not uncommon in the Salt Range carboniferous, they do not seem to be strikingly developed in the Kiol group of Kashmir, but rather to be the prominent feature of its trias formation.

The triassic rocks of Hazára are doubtless the same as some of those in Kashmir; and to judge from the description of the latter, it does not appear unlikely that the beds separated in the Sirban series as infra-trias are also included with the Kashmir formation.

For the jurassic rocks of the present district, I find no equivalents recorded in Kashmir; and the same remark applies to the cretaceous formation; though the Spiti shales of the country east and north of the Kashmir region are characteristically displayed in Hazára, with several of their fossils.

The hill nummulitic limestones so extensively developed in Hazára are not known as yet to exist in Kashmir, where, in the fringing zone of limestones outwardly flanking the Pir Panjál, the carboniferous formation takes their place in the general structural sequence.[1] But the upper nummulitic zone of the exterior of the Hazára hills is identical with the Sabáthu zone as determined by Messrs. Medlicott and Lydekker in the Jamú country and near Muzaffarábád; I have myself found it on the east side of the Jhelum north of the junction of the Nainsúk with that river[2].

From this brief glance at the want of uniformity between the extensive geological series of the two regions, it appears to follow that considerable diversity of conditions must have accompanied their formation. In regarding this possibility it should be remembered that, though the infra-jurassic unconformity, locally seen in Hazára, can scarcely be declared absent in Kashmir till

[1] In a paper and map in Q. Jl. Geol. Soc. Lond. Vol. XXXIV, p. 347, etc., I have represented this fringing zone as mesozoic as originally shown in Rec. Geol. Sur. Ind., Vol. IX, p. 155.

[2] A different view of the correlation of the nummulitic rocks east and west of the Jhelum has been suggested (Rec. Geol. Surv., India, IX, p. 57), whereby the lower or hill-nummulitic limestone is not regarded as lower than the Subáthu group, but as only a different form of contemporaneous deposits (see also Manual, p. 566).

jurassic rocks are found, there is no record in the Kashmir sections of the very complete break at the base of the Infra-trias group in Hazára. The slight and broken chain of similarities between the series commences with the lithological identity of the gneiss, is most developed, apparently, in the trias formation, and ends with the upper nummulitic tertiary group, or the far more recent Karewah beds. Excepting perhaps the most metamorphosed rocks, all the others present more of disparity than unity, and the reason for this might no doubt be found if the early history of the western Himalayan rocks and ranges were more completely known.

Mr. Medlicott has pointed out (Records Vol. IX, pt. 2, p. 51) that the elevation of the middle Himalayan area to the eastward of this country dates from early or middle secondary times, and that disturbance was specially displayed towards the close of the eocene period; but that from this early secondary date to the most recent (Siwalik) tertiary times no disturbance took place in the region of the Jhelum, that is, in a part of the country to which the present remarks refer. The later observations of Mr. Lydekker on the carboniferous series of Kashmir, indicating separated areas of deposition, and the denudation of the Attock slates of Hazára, besides the evidence afforded by the fragments of ancient gneiss in the Pangi series and rolled quartzite pebbles in the Tanol conglomerates, all these would seem to point to various stages of disturbance and repose of earlier date than mesozoic times in the western Himalayan regions; the absence also of two of the mesozoic formations, so far as distinct records go, in Kashmír, together with that of the great eocene hill-limestone so largely developed in Hazára, may possibly be connected with distribution of depositing areas consequent upon elevation in later mesozoic times. Hence the localization of the central Himalayan disturbance, with regard to the deposition of the later tertiary groups, may bear limitation to the early eocene period; and the discordance between the Hazára and Kashmír series may be due to more or less local or intense disturbances of these mountain regions at various dates from an early palæozoic to the most recent tertiary or even post-tertiary period, if the dip of the Karewahs is attributable to elevation along the Pír Panjál range or subsidence on the opposite side of the Kashmír valley.

10. *Post-tertiary deposits.*—These are not so prominently seen in Upper Hazára, as in the lower country to the south-west, but the Pakli valley and the Hazára plain are filled with detrital accumulations which may be referred to the older kind of alluvial formation. There are also semi-fan-like accumulations in the neighbourhood of Abbottabad, and thence towards Mánsahra. the original continuous surfaces of which have long since been deeply cut into by the torrential streams of the country, indicating a considerable age for these fans.

The detrital accumulations of Lower Hazára, and the Dore river are largely formed of slate debris: and the gneissic or syenitic gravel, found further west towards the Indus, has not been seen beneath these deposits. In parts of the Pakli plain, however, I found a limestone drift sometimes cemented by carbonate of lime, which appears most probably to have come from the southern mesozoic or eocene hills, as it was met with on that side of the plain.

It seems to me very probable that these deposits are of the same age as the

Karewahs of Kashmír; but I would not on that account convey the idea that they were of Siwalik or even of tertiary age.

11. *Alluvium and river deposits.*—The alluvium of the Dore and other rivers of Hazára, in low situations, is of light drab silt, not calling for particular notice. Along the Indus the river deposits occur for considerable spaces in the form of terraces, rising to more than 100 feet above the river. The material brought down by this river is also more sandy than in other cases.

A good example of the fan-form of river deposit occurs a couple of miles north of Garhi, along the lower part of a mountain torrent from the Lachikun range. The outlines of similar fans were also seen far above the highest point visited on the Indus, but within the Amb territory, which is difficult of entry without much official correspondence with the political officers.

12. *Northern drift.*—I use this term instead of the more simple one "erratic drift," which would appear to convey to some Indian geologists a closer connexion with glacial geology than is necessary to the purpose. By northern drift then is here meant that influx of travelled masses, which has followed the course of the Indus from the north, and been distributed over large spaces of the Ráwalpindi plateau, to a distance (I am informed by Mr. Theobald) of 25 miles from the river. These blocks are easily recognizable all along the Upper Indus, as far as I went, to be the same as those further down its course. They often rest on the terraces, and some of them are of very large size. They are even more numerous along the narrow part of the river valley than in the lower country. This drift of foreign or transported blocks has penetrated from the northwards up the course of the Sírun and Dore discharge, as far as the point where their united valley begins to cut across the end of the Gandgarh range; and at one or two points huge boulders of granite or granitic gneiss seem once to have almost entirely blocked the valley. One of these boulders, between the Turbela-Haripur road and the river Sirun, composed of a fine grained granitoid rock, not the Hazára gneiss, measured $22\frac{1}{2}$ feet × 36 feet × 24 feet, and has a girth of 109 feet.

The boulders are scattered over a considerable space eastward of this stream, where the ground is lower than to the west, and there is a regular drift of well-rounded gneiss blocks, often larger than paving stones, which terminates in two high mound-shaped hillocks at the upper end of the gorge near Dáre village. This disposition of the transported materials shows that many of them may have found a passage through this opening, and floated away to the southward, if rafted by ice, at a time when the Indus ran at a higher level, and most of the lower country may have been occupied by a lake. Some large limestone blocks (from what group derived being uncertain), which occur near Sultánpur on the Haripur—Hasán Abdál road, may be connected with this line of transport.

One remarkable and very large mass of the triassic or supra-trias limestone of Sirban rests perched at about 4,300 feet on the slate hills of the opposite side of the valley above the village of Sulhud. It is from 25 to 35 feet high, and 127 paces in circumference. This mass seems to have slipped from the Sirban mountain at a time when the deep valley between it and that elevation had not been excavated, and its forcible passage northward appears to have somewhat disturbed the edges of the slates forming the surface beneath. I could find upon it no traces of the action of ice, nor could I see any remains of a moraine in the vicinity. Indeed, these latter evidences of glacial agency have never presented themselves to notice in any part of Hazára I have as yet seen, though Mr. Thèobald informs me he has found glacial striæ on one of the large fragments of quartzite, a short way below. Turbela. Quartzite of the Tanol group occurs in the immediate locality, but it would be next to impossible to identify one of the stream blocks with the rock of the vicinity, or to prove the former existence of a glacier at the spot from the existence of striation under such circumstances.

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ON THE GEOLOGICAL FEATURES OF THE NORTHERN PART OF MADURA DISTRICT, THE PUDUKOTAI STATE, AND THE SOUTHERN PARTS OF THE TANJORE AND TRICHINOPOLY DISTRICTS INCLUDED WITHIN THE LIMITS OF SHEET 80 OF THE INDIAN ATLAS, *by* R. BRUCE FOOTE, F.G.S., *Geological Survey of India.*

I.—INTRODUCTORY.

THE country to be noticed in the following pages belongs partly to the Madura, Tanjore and Trichinopoly districts, partly to the native state of Pudukotai (Poodoocottah) or Tondiman. Topographically this region may be described as a gently undulating inclined plane rising very slowly westward from the delta of the Cauvery, or the sea board. It is only in the western part that the surface is broken by a few low but steep hills rising in the gneissic area, and by the lines of scarp corresponding generally with the western boundary of the lateritic formations, which occupy by far the greater part of the country now under consideration.

Hydrology.

The hydrology of this area is of very simple character, all the drainage falling in a general south-easterly direction into the section of the Bay of Bengal known as Palk's Bay, by eight principal streams. These streams are, with one exception, quite of small size, the exception being the Vaigai (Vygah) which drains the central part of Madura district. Of the others the two most northerly are really branches of the Cauvery proper; they are the Kori-ár (Coray-aur) and Pámáni-ár (Paumaney-aur), the former running parallel with, but a little distance from, the western boundary of the southern part of the delta, the latter flowing partly just within the delta, and partly within the lateritic area, this latter part of its course being apparently of artificial origin.

The Ikani-ár (Icauney-aur) which falls into the bay to the south-west of Adrampatam rises in the Trichinopoly district, close to Illipur, has a course of only about fifty miles, and is rather torrent-like in its behaviour in wet seasons.

The Vellár (Vellaur) which rises among the hills west of the Trichinopoly-Madura road, in Lat. 9° 25′ and Long. 78° 20′, is also very torrential in its character, rising suddenly in high freshes of short duration which cut away the banks or excavate side channels. According to the map (sheet 80 of the Indian Atlas), the Vellár forks, near the coast, into two branches, represented as of equal size, the northern branch being known as the Narasinga Cauvery. How the topographical surveyors came to show this phenomenon is hard to understand, for it does not exist in nature. The northern branch does not occur as shown, the so-called Narasinga Cauvery being in reality nothing more than an insignificant irrigation channel of such small dimensions that I crossed it repeatedly near Arrantangy without noticing it, though I was looking for it. The southern branch shown in the map is a genuine river, 200 to 300 yards wide and of considerable depth at flood times. Like the other rivers, in this region the Vellár proper flows in a distinctly marked alluvial valley, while the Narasinga Cauvery channel leaves the alluvium immediately below its head, and traverses an unaltered tract of lateritic sand till it reaches the coast alluvium.

Next comes the Pambár (Paumben-aur), which rises to the west of Trimiem (Tirmium) in Pudukotai.

Of the three remaining streams, the Manimut-ár,[1] or Tripatur river, the Serruvayal (Hoop-aur of sheet 80), and the Vaigai, only small portions of their courses lie within our area. The Manimut-ár gathers the drainage of the eastern end of the Sirumallai, a considerable mountain lying to the north-by-east of Madura, and of the hills lying north of Nottam in Madura and Trichinopoly districts. The Serruvayal rises on the high ground east of the Trichinopoly-Madura road near Melur (Mailore), and the Vaigai (Vygah) takes its origin at the head of the great Cambam valley on the eastern side of the Southern Ghâts. The headwaters of the Vaigai drain only the eastern scarp of the gháts which receives but a very limited supply of rain, the watershed of the whole mountain mass lying in this quarter along the easternmost ridge, hence the river is of much less volume and importance than might be expected.[2]

Geological formations met with.

The geological structure of the area here treated of is as simple as its topographical features, all the rocks met with being referable to but six divisions, which are here given in their descending order:—

6. Soils and subaërial formations.
5. Alluvial formations, marine and fluviatile.
4. Lateritic conglomerates, gravels and sands.
3. Cuddalore sandstones, grits and conglomerates.
2. Upper Gondwána beds. Hard mottled shales.
1. Gneissic or metamorphic rocks.

[1] The name Vershalay-aur given to the Tripatur river on sheet 80 is not recognized by the natives for the upper or middle part of the course. They all call it the Manimut-ár.

[2] A noble project for turning into the Vaigai the surplus waters of one of the principal rivers now flowing to waste in the Cochin backwater has been long and earnestly recommended by the Madras engineers. As the south-west monsoon rains never fail completely on the higher ridges of the ghâts, this project of throwing a vast supply of water across the present watershed would, if carried out, confer an immense boon upon the hot and now too often drought-stricken plains of the Madura country.

The gneissic rocks occupy the western part of the area to be described, and form the highest prominences in it. Amongst them are the line of hills stretching from south of Kolatur (Colatoor), south-south-westward to the Pudukotai-Illipur road, near Annavassel; and several small granite gneiss hills to the south of the Vellár, at and near Trimiem. Between the valley of the Manimut-ár and that of the Vaigai at Madura, a number of hills of small height, but often of very striking outline, occur dotted about at no great distance from the eastern boundary of the gneissic area. Between these hills the general surface of the gneiss country is gently undulating.

The gneissic series.

A considerable part of the surface of the gneissic rocks is occupied by debris of the younger overlying rocks, which have been in greatest part destroyed by the denuding agency of atmospheric forces.

The rocks assigned to the Rájmahál section of the Upper Gondwána system are very slightly exposed, and their contact with the gneiss was not visible, but there is no reason from the analogy of other parts of the Coromandel coast to imagine that their base rests on anything else than the gneiss.

Rájmahál secondary rocks.

The Cuddalore sandstones and grits rest, wherever their base is exposed, on the irregular surface of the gneissic rocks, and are themselves overlaid by lateritic conglomerates, gravels and sands, the relations between the two being extremely obscure from the great petrological similarity of two of the principal members of either group, and from the exceedingly limited number and unsatisfactory character of the sections in which the two series are exposed in juxtaposition.

Cuddalore tertiary rocks.

The total absence of organic remains from both series greatly increases the difficulty of dealing with them. The unconformity of the two groups is inferred from the extensive overlap of the younger of the two. The stratigraphical phenomenon of overlap generally involves unconformity between the formations affected by it, but no positive physical necessity exists that there should be such unconformity in every case, and I have been often strongly tempted to think that in this region it is a case of non-proven. Only one section was seen in which unconformity could be demonstrated, and in several of the best sections there is a passing of true mottled grits, which may belong to either group, into lateritic conglomerates of the most typical character, instances of which will be adduced further on.

The Cuddalore conglomerates, sandstones, &c., appear to be the lower part of one formation; the lateritic conglomerates (mostly), gravels and sands the upper part of one and the same group of rocks; mottled grits of both ages apparently lying in between.

The conglomeratic beds of both groups occur in the western[1] parts of the areas, and generally close to the boundary, at which they are mostly well displayed.

The gravelly and sandy members of the lateritic group occupy the eastern part of the slope, and sink in most cases very gently below the delta of the Cauvery, or the coast alluvium.

The lateritic rocks.

[1] North of our area the conglomerated forms are best seen along the northern boundary of the formation between Vellam and Tanjore.

The lateritic area is divided by the alluvial valleys of the several rivers above enumerated into various patches, of which the most northerly are by far the largest in area. These patches will be found described and named further on.

The alluvia.

Of the alluvia there is very little to say. Only a strip of the southern part of the Cauvery delta was examined. The marine alluvium forms but a very narrow belt in the Adrampatam[1] corner, and the river alluvia are of no great extent or importance. Owing to the great extent of wet cultivation carried on along the various rivers and under tanks constructed across their tributaries, the apparent area of the alluvium has, in the course of many centuries, been largely increased by the formation of artificial alluvial spreads, the boundaries between which and the true alluvia it is in very many, if not in most, cases impossible to determine with any accuracy.

The several rock groups will be most conveniently studied by taking them in ascending order.

II.—THE GNEISSIC OR METAMORPHIC ROCKS.

Granular quartzose gneiss.

The prevalent form of gneiss in this region is quartzo-felspathic micaceous granitoid or semi-granitoid gneiss, of pinkish or greyish-pink colour. In texture it varies from a massive, coarse, highly granitoid rock to a schistose gneiss nearly akin to mica schist. A very marked variety which is of common occurrence is a coarse granular quartz rock very rudely bedded and showing numerous small indistinct cavities from which some mineral has been weathered out. In some cases these cavities are filled with an earthy form of dark red or brown hæmatite. The cavities lie in the planes of lamination (coinciding with the bedding), and indeed but for the cavities the lamination would not be visible in most cases. The mass of the quartz is in places not unfrequently very translucent and vitreous in texture.

Hornblendic varieties of gneiss are very much less common in this region, and talcose or chloritic schists were nowhere observed. Ferruginous schists are extremely rare; no example of hæmatite schist was met with, and only one example of magnetite schist.

Finely banded granite gneiss of dense grain occurs here and there largely, as at Tirkornum, west of Pudukotai, and at Ammachattram on the Trichinopoly road.

The line of hills already referred to (page 143) which cuts the Trichinopoly road south of Kolatur, and forms the Alurruttimallai[2] and Narthamallai, consists of banded slightly hornblendic granite gneiss of pale grey color weathering to pale dirty flesh color, and showing characteristic bare rocky masses. Tors are not remarkable, or abundant, but there is much weathering along the lines of

[1] Properly the name of this place should be called Adivira-rama-patnam.

[2] The Alurrutti Mallai or "Man-rolling hill" obtained its name from the practice adopted in former times of executing criminals by rolling them over the great precipice on the south side of the hill. The hill is about 400 feet in height, and the upper part of the great south scarp overhangs slightly.

outcrop and along the plane of an important joint occupying a nearly horizontal position, giving rise to numerous low caves and rock-shelters which are yet used for various purposes by the field labourers. The basset edge of the bedding coincides with the run of the hills, and the dip is westerly. A good specimen of a rock-cut Hindu temple is to be seen on the east side of Narthamallai, and near it are some large holes, now full of water, formed apparently by the weathering out of lenticular masses of more perishable rock.

The Annavassel hills are of very similar petrological character, and so also is the bold rocky mass of the Kudumimallai (Kodemeahmallai), four miles further to the south-west, so called by the natives from a fancied resemblance to the lock of hair worn by orthodox Hindus at the back of their heads.

These hills are almost bare of vegetation owing to their very rocky character, but to the east of Narthamallai is a ridge of the highly crystalline quartzose rock above mentioned, which crumbles by weathering into a coarse grit thickly covered by heavy thorny scrub. Very little rock is to be seen here, and the contrast between the two ridges is very marked. The bedding of this quartzose rock is very obscure, but still traceable by the lines of hæmatitic grains which form discontinuous laminæ. A precisely similar rock, probably the extension of the same bed, is to be seen a little south-east of Pilliur (Pilleoor), eleven miles to the north-east-by-north. No other minerals could be traced in this rock. This band of granular quartzose gneiss shows also strongly to the east of the Annavassel hill, and is doubtless connected with more southerly outcrop of similar rock, as, for example, that on the south bank of the Vellár, close to Kemanur. Still further south this very peculiar variety of gneiss occurs largely, and forms several low hills and ridges which, though nowhere of any height, are yet conspicuous from their light color where not covered by jungle, or from their being crested by narrow ridges of bold blocks and tors. Among these the following are noteworthy: the Neddamurrum hill, three miles north-east of Tripatur, the Manmallai (Munmullay), the north-eastern extremity of a long low ridge which crosses the Tripatur-Sivaganga high road, and may be traced for some thirteen miles to the west-south-west. This, which in parts is crested by a row of striking tors, forms for a distance of fully ten miles a perfectly straight boundary line on which the western edge of the Sivaganga (Shevagunga) lateritic patch abuts.

Another ridge, about 250 feet high and three miles long, lies between two and three miles north-west of the Manmallai, and is locally known as the Yerimallai. In both these ridges the beds have a very high westerly dip, ranging from 75° to nearly, if not absolutely, vertical. Very similar to both these ridges is another which abuts on the left bank of the Vaigai river, about four miles south-east of the town of Madura, and which extends east-north-east towards and apparently joins the row of huge tors which culminates in the Trivadur trigonometrical station hill. Besides the outcrops of the granular quartzose gneiss above mentioned three other occurrences of it should be noted; these are a band occurring about two and a half miles east of Tripatur, which is possibly a continuation of the Neddamurrum beds before referred to. The gneissic rock seen in the inlier south of Trimiem is a similar granular quartzose variety, the crest of a basset edge from which the overlying laterite has been denuded.

Unconnected with any of the above beds is a band of the granular rock at Mallampatti (Mullumputty), forming a low rocky ridge. The bedding in this case is extremely obscure and doubtful.

Granite gneiss outcrops.

A great show of beautifully banded micaceous granite gneiss is to be seen at Virallimallai, a bold rock crowned with a temple of some note about twenty miles south-west of Trichinopoly on the high road to Madura. The lamination is in parts greatly contorted and "vandyked," and the pink color of the rock, banded with shades of grey and occasional black micaceous laminæ, forms a stone of striking beauty. A similar banded, but paler colored hornblendic granite gneiss is very largely quarried at Puliarpathi (Pooliarputty), four and half miles east of Tripatur. The rock here has, however, undergone much less contortion, and the beds run in a simple ridge coinciding with the strike. These beds appear to underlie the granular quartzose beds which form the Neddamurrum hills above referred to.

Among the more noteworthy outcrops of granite gneiss in the northern part of our area is a band of a pale grey micaceous variety which forms some large tors and bosses at Killumallai (Killumalla) in the northern corner of the bay of gneiss north of the Ikani-ár (Icunney-aur) valley. The general surface of the gneiss in this bay and south of it nearer Pudukotai is much obscured by sandy semi-lateritic soil. Gneiss crops up only here and there, and mostly in detached rounded bosses or "whale backs," as *e. g.*, by the Konanda Kovil bosses, and the extensive "whale backs" north-west of Shembatur.

The rock forming the Vellengoody and Kunamulla trigonometrical stations lying a little westward of the gneissic bay just referred to, and the bosses of gneiss north of Kirnur (close to Kolatur) consist also of micaceous granite gneiss distinctly bedded, especially in the former case. There the bedding is greatly crumpled, and the rock weathers of dirty pinkish color. The Kunamulla rock is more compact, less micaceous and paler in color. It is quarried, and the freshly broken rock is very handsome, banded with pale shades of bluish and whitish-grey.

Peculiar weathering of gneiss under laterite.

Where the gneiss has been directly overlaid by the conglomerates and laterites of the younger series, it mostly shows a great deal of yellowish-red (rusty) ferruginous staining and a peculiar and characteristic gritty roughness of decomposition of the surface not seen where the weathering action has taken place on the long exposed surface.

Other fine outcrops of granite gneiss occur at Suriur (Sooriore) on the boundary of the laterite about seven miles north of Kolatur, and to the west of the last place to the north and south of Naugupatti (Naungooputty), and at Shatanpatti and Rapussel (Raupoossel). There are also numerous fine examples of granite gneiss rocks to be seen on either side of the Vellár valley to the westward of Tirkornum, *e. g.*, at Permanad, Chittur (Shittoor), and Surramulla. West of the latter village is a superb tor of great height, a conspicuous object from considerable distances. East of the village several ridges of gneiss cross the river and divide the alluvial basin into two parts. The high ground south of this near Kotur is crowned by several prominent bosses standing up out of the scrub jungle.

In the southern part of our area several noteworthy ridges of granite gneiss occur, *e. g.*, at and to the north-east of Kilavaladu (Keelaladoo), also at Melur, and last but not least in size or in striking appearance is the ridge known as the Anaimallai (Annamulla) or Elephant hill, five miles north-east of Madura. This last ridge terminates at its southern extremity in a very bold bluff, bearing when seen from various points a very fair resemblance to a huge elephant, a likeness which has given it the name it bears, and connected it with the principal mythology of Madura and the famous temple of Minakshi. It is a perfectly naked rocky ridge, about two miles in length, consisting of grey and pale pink banded micaceous granite gneiss of coarse texture. The dip of the bedding is not distinct; it is, however, mainly westerly, though the northern extremity looks as if it were the remains of an anticlinal fold.

The numerous low rocky hills at and around Trimiem in the southern part of Pudukotai State all consist of coarse, generally micaceous, banded granite gneiss of pale color, varying from pure grey to pinkish or brownish-grey. Tors and great rounded blocks are numerous.

Highly hornblendic gneiss is of rare occurrence in the gneissic area between the Vaigai and the Cauvery; no important beds of it were noted anywhere.

General strike of the gneissic rocks.

The general strike of the bedding trends from west-south-west to east-north-east on the left bank of the Vaigai river, to north and south, or north-by-west south-by-east, in the neighbourhood of Illipur and near the northern limit of our area as Trichinopoly is approached.

A small tract of country over which the strike has a totally different tendency occupies the centre of our gneissic area, and extends from the valley of the Manimut-ár northward to within a couple of miles of the Pambár valley at Trimiem. In the southern part of this tract the strike varies from east-by-south west-by-north to north-west-by-west south-east-by-east; in the central part no well-bedded rocks were mapped, but in the northern part the strike changes from east-west to east-by-north west-by-south.

Magnetic iron bed.

Only one occurrence of magnetic iron in the gneiss was met with; this was about a mile north-east of Mallampatti (Mallamputty), a village in the Pudukotai state nineteen miles north-west-by-north of the town of Pudukotai. Very little of the outcrop is seen, but a good deal of debris of a rich magnetite bed is scattered about the fields a little to the eastward of the Mallampatti granular quartzose gneiss ridge above referred to (page 146).

III.—The Upper Gondwána Series.

Analogy* with the geological structure of the more northern parts of the Coromandel coast would suggest as extremely probable the existence south of the Cauvery of representatives of the Upper Gondwána formation; and in fact two outcrops of rocks referable on petrological grounds to that series were discovered underlying the lateritic rocks in Madura district to the north-eastward of Sivaganga. The petrological resemblance of the shales which occur at a small village called Ammorsonpatti (not shown in the map) lying near Mudechampatti, ten miles north-east-by-east of Sivaganga, is very great to some of the hard shales occurring at Sripermatur and Vamávaram; but unfortunately no organic remains could be found, though very closely searched for. The shales are not seen *in situ*, but only as material turned over from the bottom of a small tank south of the village. A considerable quantity, however, was exposed in the bank of the tank in clean condition, so that the color and texture of the rock could be well studied. The prevalent colors are buff and yellow mottled with white. Some quantity was also noted of pink color, ranging to red with a crust of white about ⅛ to ¼ inch in thickness along the lines of jointing, which are sharply cut.

Ammersenpatti shales.

About a mile south-east of this spot I came upon a small opening in the heavy scrub jungle where much debris of very sandy hard shale, almost a sandstone, lay mixed up with lateritic debris; this shale, too, bears a strong resemblance to many sandy shales occurring in the northern outcrops of the Upper Gondwána series. No fossils were here observed, nor was the rock seen *in situ*, the surface at that spot being a dead flat showing no sort of section.[1] The spot where the hard sandy shale was seen is passed through by the cart track leading south-south-eastward to Kalliar Kovil.

The petrological resemblance of these shales to members of Rájmahál group (Upper Gondwánas) in the Trichinopoly, Madras, and Ongole areas is certainly far greater than their resemblance to any member of the lateritic series, or of the Cuddalore sandstone group, that I am acquainted with, but in the absence of organic remains, the age of the Ammersenpatti shales cannot be positively determined.

Very faint traces of drab or buffy shale were noted in the bank of a tank-well on the west side of the road to Tripatur, about two miles north of Sivaganga. Only small chips of the shale were found in the mass of kankary lateritic gravel turned out, and no traces of fossils could be found.[2]

Some connection exists also, unless I am mistaken, between some remarkable boulder beds, resting upon the surface of the gneiss in this quarter, and the Rájmahál beds. These boulder beds cover a very considerable surface on the higher ground north-east of Sivaganga, and south-west of Serruvayal. Their limits were not determined owing to the great defects of the map (sheet 80), and to the difficulty of doing any mapping in extensive and thick spreads of scrub jungle in the absence of any landmarks. The boulder beds are best seen along the road leading from Natarashenkottai, north-north-westward to Kolakattipatti (Colacottyputty). They appear to be due to the action of surf beating on shoals;[3] for not only do many large and well-rounded pebbles strew the surface, but the surfaces of various protuberances of

Boulder beds.

[1] This spot was only examined cursorily, as I came upon it very late in the day when far from camp, and had no subsequent opportunity of revisiting it.

[2] The country round Sivaganga deserves a closer examination than I could give it, as I was seeking to carry the boundary work southward as fast as possible. Failing health and strength, however, compelled me to seek a change which prevented my revisiting these localities as I intended doing.

[3] These boulder beds lie at a higher level than much of the gneissic area to the westward of them.

the coarse granular gneiss are worn and rounded *in situ*. Much coarse and fine lateritic debris rests on and among the boulders. No section was seen showing undisturbed laterite in clear juxtaposition to the boulder beds, but the latter bear greater resemblance to the beds of similar character forming the base of the Rajmahâl formations near Utatúr, Sripermatur, and Ongole than they do to any true lateritic conglomerate that I am acquainted with.

IV.—The Cuddalore Series.

The representatives of the Cuddalore series (established by Mr. H. F. Blanford for certain rocks in South Arcot and Trichinopoly districts) which occur in our limits consist of coarse conglomerates, sandstones and grits, the latter passing locally into a rock perfectly undistinguishable from the common laterite which so largely covers the surface in this region. Here as in so many other parts of the Coromandel coast, the slight slope of the country and the very low dip of the rocks have prevented the formation of really valuable natural sections, and civilization has not yet advanced sufficiently to have given rise to any artificial ones of importance. The extension of wet cultivation greatly militates against the formation of deep channels by the different smaller streams draining the country. All are dammed back at many points of their courses, and give rise to the formation of local alluvial flats which only add to the obscuration of the younger rocks, whose relations are therefore generally very unsatisfactorily and imperfectly displayed, so that definite information regarding many interesting stratigraphical points is at present not procurable. The total absence, so far, of organic remains renders the correlation of detached exposures of even similar rocks of great and inevitable uncertainty. These difficulties present themselves saliently in the Tanjore, Pudukotai, and Madura districts.

Thachenkurichi section.

The most northerly section in which rocks, assumedly of Cuddalore age, are to be seen, occurs to the south-east of the village of Thachenkurichi (Thachencoorchy), some six miles north of Gandarakotai (Gundaracottah) in Tanjore district. A fair show of grits and sandstones is here to be seen along the sides of a small winding stream. The sandstones occur in irregular somewhat lenticular patches of dark brown color and considerable hardness. They are overlaid by gritty sandstones mottled pale purple, yellow and rusty red. The upper beds of these are very clayey and lateritic in character. To the south-east of this section lie two small low hills, both capped with thick conglomeratic laterite, but no evidence could be found as to what underlies this capping, the sides of the hills being thickly covered with debris and thorny jungle. The sandstone beds in the stream banks and bed roll about in various directions. West of the village is a broad low ridge of ill-compacted gritty shingle conglomerate, which dips eastward under

Shingle conglomerate near Pudukotai.

gritty laterite close to the high road to Pattukotai. Similar conglomerate occurs resting on the gneiss on the high ground north-east of Pudukotai near Kunnapatti (Coonnoo-putty), and farther west near [illegible].

Along the southern brow of the same high ground overlooking the town of Pudukotai is a line of [illegible] cliffs, 12 to 15 feet high, showing conglomerate, of quartz and gneiss pebbles in a gritty, often semi-lateritic, matrix of reddish purple, color, and containing here and there small nests of clay. This conglomerate, which is not very hard, rests on the very irregular surface of the banded (slightly hornblendic) granite gneiss, to which it has imparted a strong yellow stain.

Shenkarai ridge conglomerates.

Among the more southerly conglomerate beds are those met with in the Shenkarai ridge, about eight miles south-by-east of Pudukotai. They are displayed on the western slope opposite Shenkarai village by an extensive series of rain gullies which expose a considerable surface of the gritty conglomerate; but unfortunately do not cut deeply into it. Its base is not seen, but it probably rests directly on the gneiss which shows in Shenkarai tank. The bedding is seen to dip east-north-east or east-by-north at angles of from 12° to 15°. False bedding prevails, but only to a small extent, for so coarse a rock. The conglomerate is of mottled brown to pinkish and whitish, less frequently reddish-yellow color, and tolerably compact with a gritty matrix, including quartz and gneiss shingle, from the size of a cocoanut downward, in moderate quantity. The eastern slope of the ridge [1] is overlaid by the most massive and continuous (sheet-like) bed of lateritic conglomerate that I have seen on the Coromandel coast; it covers a considerable space between Arimullum (Aurmoolum) and Malalapatti, and is itself lost sight of to the east under lateritic sands and the alluvium of the Vellár.

Further eastward, away from the boundary, the conglomeratic character of these Cuddalore beds diminishes rapidly, and very few sections are to be found that penetrate the surface laterite. Where the sub-rock is reached, it is seen to be a grit or sandstone.

Section near Ayangudi.

A second section of the Cuddalore beds forming the Shenkarai ridge was found in the scrub jungle about two miles further south-west and about a mile south-east of Ayangudi. The beds here seen are unlike the Shenkarai beds, they are conglomerates of very coarse texture and rather friable. The matrix, which varies from light red to brown red in color, is semi-lateritic and vermicularly cellular to some extent. The enclosed shingle is mostly large and well rounded; it is chiefly quartzose and all apparently of gneissic origin. The lowest bed seen is mottled and more gritty in texture with fewer enclosed pebbles. The dip is southerly at low angles. Here as at Shenkarai the section penetrates but a few feet vertically.

Section at Ammagudi.

A section in which gritty sandstones are seen peeping out below the surface laterite occurs close to Ammagudi (Anmagoodey) on the left side of the Vellár valley, some four miles north-west of Arrantangy. Brown and purple sandstones occur here of sufficient hardness locally to be quarried into coarse flags. They are exposed in the gentle scarp below the laterite.

Section at Sivaganga.

The last outcrop but one of Cuddalore rocks to be mentioned occurs to the south-east of Sivaganga, [illegible] a mile and a half from the town, where several beds of hard thick-bedded grit crop

[1] The topographical features of this ridge are very [illegible] shown in Sheet 80, where it appears of considerable height instead of as a mere low rise marked [illegible] a short distance at its northern extremity. Extensive scrub jungle covers the greater part [illegible] surface thickly.

out from below the general lateritic covering of the country. In color the rock is dark purplish-grey with brown bandings, and so hard as to be worked by blasting The beds have a north-easterly dip of about 20°. Much diagonal or "false" bedding is seen in the fresh broken specimens of the rock, which is overlaid conformably to the eastward by less compact dark-brown and yellow-brown grits. The hard grits are largely quarried as building stones. Unfortunately no laterite is seen in juxtaposition with the grits, so the local stratigraphical relations of the two rocks cannot be studied.

Section at Perungalur.

The best section of Cuddalore grits of the softer variety occurs about eleven miles north-east from Pudukotai, a little west of the high road to Tanjore. Here the small stream which feeds the Perungalur tank, in descending from the high ground to the north, cuts through the upper laterite beds, and exposes beds of typical grits in many gullies, forming so many miniature canons of very perfect shape with nearly vertical sides, from 12 to 18 feet deep and only 2 or 3 feet apart at the bottom. The grit beds show a rude but distinctly columnar jointing strongly resembling starchy cleavage on a huge scale.

The section here displayed shows the following sequence of beds in descending order:—

4. Black laterite conglomerate, on gravel.
3. Red-brown vermicularly porous conglomerate, passing down into—
2. Brown conglomerate with many pebbles of quartz-grit and older laterite.
1. Grits, pale mottled, generally showing columnar jointing with vermicular tubes and scattered galls of fine clay.

In this section distinct unconformity is seen to exist between Nos. 1 and 2. No signs of organic remains could be traced after very careful search.

A small show of rather soft grit of red and brownish mottled color appears between the boundary of the gneiss and the overlying laterite between Surianpatti (Pothanavial of the Atlas map) and Parembur in the south-western corner of the Tanjore patch.

Mottled grits which on petrological grounds are considered as of Cuddalore age are exposed, in sections of wells and deep tanks, under the laterite conglomerate at Palatur (Pullatoor) and Shuragudi (Shooragoody) in the Shahkotai patch of the lateritic formations (see page 153).

Age of boulder beds.

The boulder beds described above (page 148) as occurring to the north-east of Sivaganga may possibly be of Cuddalore age, or tertiary, instead of Rájmahál age, or secondary, as there is no positive evidence either from the presence of organic remains or speciality of stratigraphical position, but in their facies they are decidedly much more akin to the older series.

V.—The Lateritic Group.

The Cuddalore series is overlaid by the several members of the lateritic series, which vary from hard typical conglomerates through gritty beds to gravels and finally to reddish sands with variable quantities of gravelly pisolitic hæmatite concretions. The sandy beds occupy the lower slopes near the delta or the band of marine alluvium bordering the coast, while the conglomeratic beds occupy the higher grounds to the west and often overlap widely on to the gneiss.

Sub-division of lateritic area.

The various rivers which convey the drainage of the country to the sea divide the lateritic region into a number of minor areas or patches amounting in all to nine. Their sizes are very unequal as might be expected, ranging as they do from several hundred square miles to only a few dozen or so in extension. Taking them from north-east to south-west the first is the *Tanjore patch,* so called from the fact of its being the southward continuation of the great patch, on the northern edge of which stands the famous old town of Tanjore, five miles beyond the northern limit of the map. This is followed southward of the Ikani-ár by the *Pudukotai patch,* which is divided by the Vellár from the *Shenkarai patch.* South of the Pamb ár lies another patch of laterite which I will designate as the *Sháhkotai* (Shawcotta) *patch.* South of the Manimut-ár is a small patch which may conveniently be called the *Serruvayal patch.* The most southerly spread of lateritic rocks to be described lies around Sivaganga and should be named accordingly the *Sivaganga patch.* Two of the remaining patches to be considered lie to the westward of the general run of the patches close to the town of Tripatur, after which they may be suitably called the *north* and *south Tripatur patches.* The ninth and last patch lies at the western extremity of the Tanjore patch on the border of the country included in sheet 79; it may for convenience be called the *Nallur patch.* A great number of little patches too minute to be mapped are dotted over the gneiss area at various distances from the present laterite boundary, showing that its former westward extension was considerably greater than it is at present, and that great part of the original deposits has been removed by denudation Some of the smaller of the far outlying patches have undergone so much change from weathering and reconsolidation that they might almost be reckoned as subaërial formations.

Tan[illegible]

The most remarkable spreads of conglomeratic laterite are to be seen along the western boundary of the areas in nearly every case, but only a few of them need be specially mentioned. To begin with the [illegible] seen to the west and s[illegible] patch. Vast sheets of laterite conglomerate are to be [illegible] patti[illegible] especially the bare [illegible] of Gandarakotai. A little to the north of Suriam- [illegible] sheets of rock arranged in terraces with low steps give the country a strange app[illegible]earance. Where the conglomerate is covered with soil the latter is generally a very [illegible] and compact sandy clay of red or yellow (bath-brick) color much marked by [illegible] cracks, which run in very regular systems and give the soil a tesselated appearance on a large scale. In the presence of water these lateritic soils are [illegible] they are oftenest [illegible] are generally [illegible] low scrub of *Dodonæa* [illegible] mixed with a few dwarf [illegible]

This low *Dodonæa* [illegible]

and many [illegible] of it [illegible] soil tracts, not unfrequently very much the appearance of a gritty sandstone without, however, actually possessing sufficient cohesion to deserve the name of rock, though in some cases it very nearly merits being so called. A good example of this may be seen at Nadduveykotai, four miles west of Pattukotai (Puttucottah).

Pudukotai patch.

Passing over to the Pudukotai patch striking spreads of hard typical conglomerate are to be seen in many places near the western boundary and even at some miles distance from it, *e. g.*, at Urriur in the extreme north-west corner of the patch, also nearly all along the left side of the Vellár alluvium valley close down to Arrantangy, and to the north and north-west of Alangudi (Aulangoody)

Shenkarai patch.

The Shenkarai patch contains, as already mentioned above (p 150), an extensive and massive development of conglomerate in the eastern slope of the Shenkarai ridge and the plain east of it. This great development of conglomerate is continued under the alluvium of the Pambi-ár and re-appears in the Shahkotai patch and is specially well seen at Kilanellikotai (*Koelnellicottah*), where the walls of the extensive old poligar fort are built of the massive laterite quarried close by. The conglomerate is also admirably seen on the bluff east of Neddengoody, which may be regarded as the continuation of the Shenkarai ridge south-westward. From this bluff which is crowned by a picturesque temple called the Padikása Nadar Kovil, the ridge declines and is lost to the south-west in a high-lying plain of massive laterite extending without a break to Palatoor (Pullatoor). The high ground between Shuragudi (Shooragoody) and Káragudi (Caurgoody) is also covered by a vast sheet of laterite conglomerate, as are also the high ground to the west and south-west of Káragudi near Yalengudi and Kutalur (Coothaloor). The conglomerate is mostly very richly ferruginous for a laterite, and there are abundant traces of a once existing active iron smelting industry Large quantities of iron slag have been scattered about in many places where now no iron is made.

Shahkotai patch.

Serruvayal patch.

In the Serruvayal patch of lateritic rocks highly ferruginous conglomerate covers a large space between Serruvayal and Kalel (Cullel), also near Páganeri (Pauganary).

Sivaganga patch.

In the Sivaganga patch spreads of conglomerate of considerable extent are frequently met with, *e. g.*, to the north-west of the town, to the east around Natarashenkotai, to the north-west of Kalliar Kovil, and in the northern corner of the patch near Wukur and Tiruvenpatti (Tirroovenputty).

Tripatur patches.

In the two patches north and south of Tripatur the dense and highly ferruginous form of the laterite conglomerate is less developed, and a [illegible] ferruginous and [illegible] compact form, including [illegible] shingle, prevails.

N[illegible]

The N[illegible] westernmost [illegible] the Tanjore patch [illegible] gritty and [illegible] less compact form [illegible] over the spreads above enumerated. The rock is perhaps [illegible] but owing to its gritty character shows a rougher duller surface with many fewer vermicular cavities. The larger enclosed fragments of older rocks, which consist almost entirely of gneissic quartz, are mostly subangular or angular, giving the rock a breccia-like appearance. Well-rounded pebbles do, however, also occur. A conspicuous example of such a breccia-conglomerate is that occurring to the west of Payakudi in the north-western corner of the Tanjore patch.

The outlying patches of laterite conglomerate resting on the gneiss in the northern part of our area agree generally in character with the gritty variety just described, but those in the south-westerly part are of the more typical form with many vermicular cavities in the more clayey mass. The southern patches when very conglomeratic contain chiefly well-rounded water-worn pebbles, and approach in coarseness to some of the typical conglomerates of median texture in the Madras region, in which stone implements occur. Whether stone implements occur in this southern laterite is a question to which a positive answer cannot yet be given, no unquestionable examples having as yet been found I did, however, find occasional specimens of coarse quartzose stone which bore a resemblance in shape to various forms of chipped implements common in the more northerly gravels and conglomerates, but the material is so coarse that the chipping could not be considered as positively artificial. The most undoubtedly artificial specimen was a broad axe-head found about a mile north-north-west of Shuragudi in the Shahkotai patch. Occasional fragments of chert derived from unknown sources occur scattered sparsely over the surface of the lateritic conglomerates. Three specimens of this chert appear to be of artificial shape, one is a flake of small size resembling an arrow-head, the second a small prismatic core, the third a thick oblong sharp-edged flake with a distinctly serrated edge to one of its longer sides.

Several large leaf-shaped flakes, almost deserving to be called implements, were found by me between Vellam and Tanjore, only a little distance north of the line forming the northern limits of sheet 80. Two of these were adherent to the surface of the conglomerate and appeared to be genuine exposures *in situ.* They had to be hammered out of the rock.

These large flakes appear to be made of a chert identical with that forming the great fossiliferous blocks lying in the mottled grits occurring to the east of the old fort ditch at Vellam.[1] The small implements above mentioned are made of a much more jaspery-looking variety of chert.

I cannot help thinking that closer search of the shingly lateritic beds such as that at Tallakolum (Tullahcolum), north of Madura, and those occupying so large a part of the two Tripatur patches, would lead to the finding of unquestionably recognizable specimens of chipped implements.

Of the very numerous spreads of lateritic gravelly sands which occupy the eastern part of the lateritic area, the most [illegible] is that cut through by the Pamani river at and to the south of [illegible] district, which also extends close down to the [illegible] at [illegible].

[1] See Mem., G. S. I., I, IV, p. 92. [illegible] was made in 1878 to supply, as far as possible, the [illegible] by the wreck of the [illegible] in 18[illegible].

The section of these sands in the bank of the Pámani-ár at Kara-ká-kád (not in the map), a little village about a mile north-east of Painganád (Pynganaud), shows the following succession of beds:—

Kara-ká-kád section.

Local alluvium	... ...	1½′—2′
Gritty sands	... ...	2′
Ferruginous gravel with quartz fragments	...	4′ (exposed).

Character of the ferruginous gravel.

The gravel is formed by accretion of quartz grains (sand) with a brown hæmatitic cement into rudely rounded lumps generally about the size of a hazelnut These lumps are here, and generally in the eastern part of the lateritic area, unglazed and dull in appearance; further west, however, the lateritic gravel is generally glazed and externally smooth even when fracture shows the interior to be gritty. The shiny glazed form is also seen in the lateritic sands of this part of the country, and a half glazed form is not uncommon.

Where bare or but thinly covered with vegetation, the surface of the bands is often covered by thin sheets of this ferruginous gravel, from which the sandy and clayey portions of the original bed have been removed by fluvial action. Where the thickness of the gravel beds has become considerable, subaëreal consolidation not unfrequently sets up, specially where the glazed form of the gravel occurs.

Passage of lateritic sands into grit.

In the northernmost part of the Tanjore area within sheet 80, in the tract lying along the high road from Tanjore to Adrampatam, the lateritic sands are seen to pass down into typical soft grits of pale color containing but little ferruginous matter. These grits may be seen at the villages of Kovilur (Coviloor), Karkankotai (Curkancottah), and Ulur (Woolnoor). The sections, which are only in the sides of wells, are neither deep nor clear enough to show the relations of this pale grit with the undoubted Cuddalore beds.

Loamy beds.

The whole of the eastern part of the lateritic area is not everywhere covered by sandy beds: some considerable tracts, *e.g.*, around Pattukotai (Puttucottah) are occupied by rather hard red loam containing variable and sometimes considerable quantities of lateritic gravel of the non-gritty glazed variety. This hard red loam graduates into the sandy form imperceptibly. It is generally confined to the higher grounds.

The bottoms of the shallow valleys which drain the area occupied by the softer members of the lateritic series are frequently occupied by swampy ground or by small quicksands, very unpleasant to a guideless rider, and the higher parts are not unfrequently very sandy.

Flora of lateritic region.

The flora of the lateritic area differs in the eastern parts considerably from that of the gneissic region and of the high-lying area covered with hard conglomerate or quasi-baked clayey soils. The sandy eastern parts support very extensive plantations of cashew-nut trees (*Anacardium occidentale*), with very frequent clumps of bamboo and pandanus. *Calophyllum inophyllum* occurs also more frequently here than in any other parts of Coromandel [illegible] I am acquainted with. The jack tree (*Artocarpus* *nitigrifolium*) is also cultivated to a very great extent all over the lateritic area, but some of these trees are common on the gneissic area.

Of minute plants one of the most characteristic, which occurs in immense numbers in low lying damp sandy flats, is a small *Drosera* or sundew, though elsewhere a very rare plant in the low country. A zoological peculiarity of the lateritic sandy region is the great frequency of a large *Spongilla*, or freshwater sponge, in many of the shallow rain-fed irrigation tanks. Nowhere else have I noticed this sponge to be common or to attain to anything like the size it does in this quarter.

Alluvial Formations.—The alluvial deposits coming within the scope of this paper are of small extent, as only a small section of the south-western corner of the Cauvery delta was examined, and the alluvia of the various small rivers traversing our area are very limited.

The western part of the Cauvery alluvium is formed of a black clay, apparently a true regur, becoming gradually sandy as the sea is approached. No section penetrating through this black clay was seen within the limits of sheet 80, but a fresh excavation for the foundations of a new sluice branching off from the Pamani-ár just within the area of sheet 79, on the road from Manárgudi to Neddamangalam railway station, revealed a bed of very stiff blue clay full of small kankar (gravelly tufa).

The alluvia of the smaller rivers is generally a whitish mixture of sandy clay with lateritic pellets and small debris of quartz and gneiss. The flats are often slightly swampy, or barren, and unproductive from the saline matters enclosed. An exception to the whitish alluvium is offered by the alluvium of the Manimut-ár below Tripatur, where low cliffs of reddish loam form the river banks for a couple of miles or more above Neddarakotai. The alluvium of the Vaigai appears to be generally sandy, but no sections were seen, and from centuries of wet cultivation the whole surface must be looked upon as really "made ground."

The coast alluvium near Adrampatam is generally clayey near the surface and edged with a narrow strip of ill-defined sandhills. No sections of the coast alluvium were seen.

Soils.—The soils depend almost everywhere on the underlying rocks for their character. Red and reddish sandy soils abound. Black soil is not at all common. It occurs largely only over the western side of the Cauvery delta, and under a few important irrigation tanks where it must be regarded as of artificial origin. Whitish clayey soil very similar to the pale alluvia of the large streams is met with in many valleys of the eastern lateritic areas, and, as above mentioned, often forms small treacherous quicksands most disagreeable to the rider.

Where the conglomeratic laterite occurs two forms of soil prevail, both of them hard clayey sands, the one of bright red, the other of pale yellow (bath-brick) colors—often approaching in texture to true sandstones. Many large spreads of these occur covered with low scrub of *Dodonæa viscosa* and a few dwarf mimosæ and other thorny bushes, e. g., on the high ground to the south of Gandarakotai in the Tanjore patch, and again on the high ground north-east-by-east of Alangudi in the Pudukotai patch. The surface of the soils is often covered with light wreaths of grit and sand collected by the prevailing winds.

The red soil is the more common form, but both it and the yellow variety show frequently on the hardest parts of the surface a semi-metallic-looking blush of bluish-black color

Over the lateritic bands the soil is generally a nearly pure, less frequently somewhat clayey, sand.

Real blown sands were very rarely noted within the limits of sheet 80 as far as the survey extended; those in the little strip of coast examined in the Adrampatam corner of Palk's bay are hardly worth noticing, and the same may be said of a few low hillocks on the bank of the Vaigai river near Tirupavanam (Trippawanum) The most notable accumulation of sand raised by wind was seen between Vadakur (Vuddacoor) and Pinneyur, three and half miles southwest of Ortenád Chattram (Mootooaumaulpooram of the Atlas map). The hillocks here are of very small extent, but rise from 15 to 16 feet in height; they are limited to a very small superficial area.

Economic Geology —Few districts even in the poor region of Southern India are so extremely destitute of valuable minerals as the country dealt with in these pages. Building-stones, road-metal, and kankar for lime-burning are at present about all the material collected for economic purposes, with the exception of a little impure salt and saltpetre.

Iron used to be smelted in some quantity from ores obtained from the lateritic conglomerate beds as testified by the quantities of iron slag scattered over the country and here and there accumulated in large heaps. Of late, however, this industry seems to have died out entirely, for I could not hear of its being now followed anywhere, nor did I come across any villages in which smelting furnaces were still in operation.

The compact richly ferruginous laterite conglomerate furnishes endless material for rough building purposes, and is even carefully cut and dressed for better class buildings now put up at various places by the rich Natukotai Chetties, a caste of rich traders and soucars who are buying up much land in many villages on the lateritic area and building palatial houses in every direction, besides tanks and temples. Many old buildings of importance have been built of this stone, *e. g.*, the great fort at Kilanelikotai and the fort at Arrantangy. The laterite of the Shenkarai patch and the northern part of the Shahkotai patch yields the largest and apparently the most reliable and homogeneous blocks I have seen quarried anywhere between Cape Comorin and the Kistna river.

Of gneissic rocks the Puliarputti banded gneiss is the most largely used. The great quarries four miles east of Tripatur are largely worked for blocks of all sizes, up to nearly 30 feet in length. The stone is in great demand because of its beauty and moderate price owing to its being easily quarriable. Large pillars about 12′ by 3′ by 1′ 6″ roughly dressed for the gates of pagodas or mantapams cost only Rs. 30 on the spot.

Very handsome granite gneiss is quarried at Tirkonum, west of Pudukotai, and at Kunamulla trigonometrical station hill, fourteen miles to the north. The granite gneiss at Virallimallai, twenty miles south-west of Trichinopoly on the Madura road, could yield stone of very great beauty if required (p. 146). Less handsome, but very useful stone is quarried from the granite gneiss rocks occurring at Trimiem in Pudukotai State, and at foot of the Anaimallai near Madura (p. 147).

My stay at Madura was too limited to allow of any enquiry into the question of the localities which yielded the splendid black hornblendic rock forming the noble pillars to be seen in Trimal Naik's palace, one of the most remarkable buildings in India. The quarries which yielded this stone and the hornblendic rock carved into the many bold striking figures and statues in and about the great Madura pagoda were not among those seen by me, and doubtless lie beyond the limits of the gneissic area surveyed.

Some of the finest and boldest carvings, both of statues and scroll work that can be met with in Southern India, are to be seen at the Avadiar Kovil, or temple, in the southernmost corner of Tanjore district The great mantapam in front of the temple gate is an architectural work of great beauty and noble proportions, far better worth photographic illustration than many other buildings that have been made known to the public. Unfortunately it is so much off the beaten track that very few know of it, and hardly any one visits it. The stone used is said to have been brought from Trimiem and Tirkornum, but is more hornblendic than any of the rocks seen at those places.

The great temple at Manárgudi, on the western edge of the Cauvery delta, is largely built of gneiss from an unknown locality, but which must have been brought a distance of fully fifty miles, supposing it to have come from the very nearest quarries, those of Mammallai, eight miles east-south-east of Trichinopoly. These quarries may well have yielded all the slightly hornblendic pale stone used at Manárgudi and also at the great Tanjore temple, excepting, probably, the famous great bull and a few other large monoliths of much more hornblendic character. It is not known for certain where these were quarried, but I suspect they came from a bed of very hornblendic gneiss at foot of the Pachamallais near Perambalur in Trichinopoly district. My reason for suspecting this is, that when at Tirumanur in 1878, on the left bank of the Coleroon to the north of Tanjore, I saw several very fine monolithic blocks of dark black hornblendic rock lying on the river bank. These were said to have been brought there by the late Rajah of Tanjore from a quarry close to Perambalur to be used for a temple which was never built. This very black stone much more resembles the black monoliths in Tanjore pagoda than anything yielded by the quarries south of the Cauvery.

Great complaints are made in the southern taluqs of Tanjore district of the want of proper road-metal for the roads in those very sandy regions, but this difficulty might be largely met by screening out the lateritic gravel which occurs in large quantity in the sands in very many localities along the Manárgudi and Adrampatam roads.

ROUGH NOTES ON THE CRETACEOUS FOSSILS FROM TRICHINOPOLY DISTRICT, COLLECTED IN 1877-78, *by* R. BRUCE FOOTE, F.G.S., *Geological Survey of India.*

The following notes have reference chiefly to the fossils I collected in 1877 from the Utatúr and Arialúr groups, at Utatúr, Maravatúr, Odium, Arrialúr, and Mallúr, which alone received any careful examination. The fossils from the other localities received as a whole merely cursory inspection while being arranged for numbering. The term "new species" that will be found used here and there implies only that the fossil does not agree with the figures and descriptions of species described by Dr. Stoliczka in the Palæontologia Indica

Sponges.—A special feature of the collection is the large number of sponges it contains as compared with the far larger collection originally made at the time the geological survey of the district was being carried out. Dr. Stoliczka figures only two, which he refers to the genus *Siphonia.*

Among the sponges collected by me are numerous specimens belonging to the very important and characteristically cretaceous family of *Ventriculites.* These were found mostly weathered out of a bed of limestone south-west of Maravatúr (*Loc.* 10), very low down in the Utatúr group. They belong apparently to three species, or varieties, of different form and texture (*e.g.*, Nos. 5, 6, 7, 18—20, 45 and 49). Many show the characteristic network extremely well (*e.g.*, No. 49).

With these *Ventriculites* occurred several specimens belonging to another group (*? Spongites*), showing quite dissimilar texture (Nos. 8 to 14).

The same bed of limestone, which forms a small knoll, yielded a considerable number of other fossils, all of which were collected from a very limited space, only a few dozen square yards in extent. The most numerous of these were spines and plates of Cidarids; Belemnites were found in considerable numbers; a few small Ammonites, with other shells and corals, were also obtained. The large Pecten (No. 50) came from another bed rather nearer to Maravatúr.

A numerically much larger number of sponges, of a small cup-shaped group, was obtained from one of the lowest beds of the Utatúr group, exposed at head of a gully opening eastward, a few yards east of the old Madras road, ¾ths of a mile south-south-west of Naicolum (*Loc.* 3). These were found with a great number of other fossils on the weathered outcrop of an argillo-calcareous sandstone. With the cup sponges was one specimen of a mamillated species (No. 278). A large specimen (No. 32) of clavate form was also found weathered out of the same bed, but originally derived without doubt from the coral reef limestone at base of the Utatúr group.

Naicolum "sponge bed."

Two other sponges were obtained from the middle part of the Utatúr group exposed north and north-west of Odium (*Loc.* 21). Of those, which are numbered 14 and 15, the latter appears to be a *Siphonia.*

Vertebrate remains.—A number of large vertebræ, apparently reptilian, very like those of *Ichthyosaurus,* were found by me in the clays north-east of Utatúr. Nine out of sixteen lay together, in apposition, when I found them, but were unfortunately disturbed, before I had time to number them, by an officious collector, in direct contravention of his orders. The others had been washed down the slope of the rain gully in which they were exposed, but they all doubtless belonged to the same individual. I have had no opportunity of comparing them with figures of known *Ichthyosaurus* vertebræ. They are numbered *O*47—63.

The seven shark's teeth (marked *O*43) belonged, I believe, to the shark that yielded the large vertebræ Nos. 34—40. They were all found quite close together, weathered out of one of the large earthy ferruginous concretions, at only a short distance from the large reptilian vertebræ.

A novelty among Utatúr fossils is the *Ichthyodorulite* (No. 46*O*).

Rhyncholites.

Mollusca.- The chief novelties are several *Rhyncholites,* or mandibles of Nautili, belonging to two if not to more species. Three of small size, not well preserved, were obtained from the outcrop of the "sponge bed" (*Loc.* 3). Two others, one large, of rather different form (*Nos.* 24 *and* 25*O*) were found in the Utatúr clays. Two other peculiar bodies (*O* 26 *and* 27) bearing some resemblance to *Rhyncholites,* but both apparently somewhat broken, were also found in the Utatúr clays.

Fruit-like body.

Embedded in the clay filling the body-chamber of a nautilus from Utatúr is a singular body (No. 23*aO*), somewhat fruit-like in appearance, that I was unable to determine. I wish to draw special attention to it.

Belemnites.

From the same locality (*O*) came what appears to be a new Belemnite (*O*28) of short squat form and blunt pointed, quite unlike any figured in the Palæontologia Indica. It is much the rarest form of all occurring in the Utatúr clays.

The long, thin, sharp pointed Belemnite (No. 31) occurs chiefly in the higher clay beds.

Interesting specimens of Belemnites are numbers 67, 68, and 69 from Odium (*Loc.* 21), parts of phragmocones, the latter of very large size. No. 70 shows great part of the pro-ostracum.

Ammonites.

Among the *Ammonitidæ* No. 88, from Anapadi (*Locy.* 15), may be a new species, for it does not agree with any of those figured by Stoliczka.

Of the rare form *A. kalika* founded by Stoliczka on a unique specimen from the Arrialúr beds east of Utakoil, a second example (*OK* 16) was found by me at the same place. It is in good preservation.

Of another rare form, *A. ætra,* based by Dr. Stoliczka on two specimens from Cunum, a third example was procured at the same place. It is a young specimen and unfortunately much broken (20*o* 55).

Turrilites.

An apparently new species of *Turrilites* with very delicate transverse ribbings on the whorls was found by me west of Arrialúr (*Loc. A,* No 16.

Baculites.

No. 18 from the same locality would also appear to be a new species of *Baculites*, unless it be part of a *Ptychoceras*.

Gasteropoda.

Of the *Gasteropoda* that I had time to examine and to compare with Stoliczka's figures in the Palæontologia Indica, several, which I enumerate below, appear to differ to a considerable extent, and may very probably be new species or varieties—

Nerinæa, sp.	. . . .	Locy. 11[1]	No. 4
Scala, „	. . . .	„ A[1]	„ 141
Cancellaria, „	. . . .	„ „	„ 149
Velutina ?	. . . .	„ „	„ 150
Sigaretus ?	. . . .	„ „	„ 150*a*
Natica, sp.	. . . .	„ „	„ 151
Cantharidus ?	. . . .	„ „	„ 156
Thylacodes	. . . .	„ „	„ 159
Trochactæon ?	. . . .	„ „	„ 160
Dentalium	. . . .	„ ,	„ 163
Fasciolaria	. . . .	„ 21E[1]	„ 32
Solarium	. . . .	„ 24[1]	„ 63

[1] Locality 11 is north and north-west of Maravatúr.
„ A west of Arialúr.
„ 21E north-east and west of Odium.
„ 24, reef in stream half a mile below Veraghúr.

Pelecypoda.

Among the *Pelecypoda* the following forms appear to be new, *i. e.*, unfigured, by Dr. Stoliczka:—

Ostrea, sp.	. . . .	Locy. 11	No. 14
Pholodomya ?	. . . .	„ A.	„ 10
Panopæa, sp.	. . . .	„ „	„ 13
Tellina, „	. . . .	„ „	„ 27
Trigonia, „	. . . .	„ „	„ 46
Avicula, „	. . . .	„ „	„ 61
Ditto, „	. . . .	„ „	„ 62
Mya, „	. . . .	„ 21[1]	„ 47
Exogyra, „	. . . .	„ 27[1]	„ 73

[1] Locality 21 is north-west and north of Odium.
„ 27 is east of Karapády.

Plicated tubular shell.

A singular plicated tube of doubtful molluscan or annelidan origin is specimen No. 24, from the coral reef limestone near Naicolum (*Loc.* No. 2).

Echinodermata.—The small echinoderm No. 5, from the "Sponge bed" south of Naicolum (*Loc.* 3), appears to be new, as does also the encrinoid joint No. 4. The same may be said of an encrinoid joint found in the Utatúr clays (*O.* No. 64).

Bryozoa.—Two very beautiful small Bryozoa, Nos. 129 and 130, were obtained by me from the "Sponge bed" (*Loc.* No. 3). They are quite different from anything figured in the Palæontologia Indica.

Corals.—Considerable numbers of a very delicate little cup coral (*C. E.* Nos. 1—65) were found in white clays half a mile east of the Cudicád-Cullpády road, and rather nearer to the latter place. They appeared confined to a very small area, and were not met with elsewhere.

Plants.—Plant-remains, fossil-wood excepted, are very rare in the Trichinopoly cretaceous beds, but a few obscure specimens were obtained, *e. g.*—

An impression of a longitudinally ribbed stalk found at Seraganúr (S. No. 15).

A minute piece of a cycadeous (?) leaf in an indurated clay nodule from the Utatúr beds north of Cudicád (C. No. 3).

Minute fragments, apparently of cycadeous leaves, are traceable in some parts of small clayey nodules from the Utatúr beds (Nos. 67—72*O*).

Locality No. 2.—The collection of fossils obtained from this patch of coral reef limestone is a very important addition to the fauna of this rather obscure formation, which yielded but little, if I mistake not, to earlier searches. My success in procuring specimens was due to the limestone having been quarried to some extent quite recently. All the specimens found I obtained from the quarry chips, with only one or two exceptions.

Locality No. 3.—This locality, which does not appear to have been known to Mr. Blanford as a rich hunting ground, shows three sets of fossiliferous beds, the lowest being coarse calcareous gritty beds with a few fossils and many washed-up pebbles of the coral reef limestone, also some masses almost deserving the name of boulders of the same rock. On these rests the "Sponge bed," an argillo-calcareous sandstone. On this again lies a clay bed with large indurated nodules, containing occasional Ammonites and Nautili with a few other shells. These are easily distinguishable by their light color, pale yellow or buff, while the "Sponge bed" fossils and those from the lower beds are mostly of a distinctly brown color.

The fossils from the "Sponge bed" were nearly all found within a very small space of ground, on the very basset edge of the beds, or the upper two or three feet of the gritty talus. The fossils met with, beside the sponges, rhyncholites, echinoderms and encrinoid joints already mentioned, were Cidaris spines, Belemnites, small Corals, Bryozoa, Serpulæ in great variety and numbers, large numbers of *Tubulosteum callosum*, numerous Gryphæa and Oysters, and lastly, a number of small shells, both Gasteropoda and Pelecypoda, not forgetting a few small Ammonites. I do not recollect any other fossil locality in which I obtained so rich a collection, in an equally small space, reckoning the richness by the number of species.

Locality "*O.*"—Mr. Blanford, in his Memoir on the cretaceous rocks, speaks of the small clay nodules near Utatúr as hardly ever containing any fossils. This statement is, I think, rather too strong, and calculated to deter future collectors from searching one source of valuable fossils. My own experience is, that they are not common in the small nodules, but still common enough to encourage search. I got several (eleven I think) in a morning's general search, without devoting more than half an hour specially to breaking nodules. Two of the eleven are certainly valuable specimens, the rhyncholite-like bodies referred to above (Nos. 26 and 27).

NOTES ON THE GENUS SPHENOPHYLLUM AND OTHER EQUISETACEÆ WITH REFERENCE TO THE INDIAN FORM TRIZYGIA SPECIOSA, Royle (*Sphenophyllum trizygia*, Ung.), *by* OTTOKAR FEISTMANTEL, *M.D.*, *Palæontologist, Geological Survey of India.*

Last year a peculiar discovery was announced by Mr. Stur, at Vienna, on the relations of certain genera of Equisetaceous plants in the coal-formation. The observations refer also to the genus *Sphenophyllum;* so it will not be out of place to note this discovery, and to add some remarks on those plants with reference to the Equisetaceous plants in the Indian coal-beds, especially to *Trizygia speciosa.* The most common genera of the *Equisetaceæ* in the carboniferous formation are those which were described as *Calamites* (Suckow, 1784), *Asterophyllites* (Brongniart, 1828), *Annularia* (Sternberg, 1822), and *Sphenophyllum* (Brongniart, 1828). These were all described as distinct genera.

In 1852, however, Professor Ritter von Ettingshausen,[1] placed the genus *Asterophyllites,* as "*rami et ramuli,*" to *Calamites,* although, as it appears, there was no direct evidence for the proceeding. In 1869 Mr. W. Carruthers[2] united all the three genera, *i.e., Asterophyllites, Annularia,* and *Sphenophyllum* to one group under the name *Calamites,* considering them as three different forms of foliage of this one genus, although, as it appears, the author had no direct evidence for this theory.

Professor Schimper (1869) placed the genus *Asterophyllites,* which he named *Calamocladus* under the heading "*rami et ramuli foliosi,*" to *Calamites;* but *Sphenophyllum* and *Annularia* remained independent genera.

Professor Weiss (1871) again[3] urges the independent nature of all the genera abovenamed; and so does Professor Heer, even in his recent publications.

In 1874 it was shown by Professor Williamson,[4] who based his conclusion on the microscopical structure, that *Asterophyllites* and *Sphenophyllum* were very closely related genera.

In 1876 another systematical place was assigned to *Sphenophyllum* by Professor Schenk,[5] who arrived at the conclusion that *Sphenophyllum* is more related to the *Lycopodiaceæ* than to the *Equisetaceæ.*

To this Mr. Stur wrote a reply under the title "Ist das *Sphenophyllum* in der That eine Lycopodiaceæ,[6]" where he endeavoured to show that the systematical position of *Sphenophyllum* is with the *Equisetaceæ.*

So stood the case till last year, when Mr. Stur announced his discovery,[7] which was as follows: On a slab of shale were found several branches of an *Asterophyllites* with branchlets, which showed the foliage of a *Sphenophyllum (Sph. dichotomum),* and had a fructification of the kind of *Volkmannia,* (Stur). On other

[1] Steinkohlenflora von Radnitz, Abh. d. k. k. geol. Reichsanstalt, Vol. II, p. 24.

[2] In Seeman's Journal of Botany, 1867.

[3] Fossile Fl. d. jüngst. Steinkohlf. und des Rothliegenden, &c., pp. 107, 108, 2nd Part.

[4] Philosoph. Trans. R. Soc., Vol. 164, p. 41 *et seq.*, 1875.

[5] N. J. f. M., 1877, p. 435, Refer.

[6] Jahrb. d. k. k. geol. Rchstlt., 1877, Vol. XXVII, pp. 7—32.

[7] Verhandl. d. k. k. geol. Reishsanstalt, 1870, p. 327. See N. Jahrb. f. Min., &c., 1879, pp. 256 and 260.

specimens the same *Asterophyllites* is said to have a fructification of the kind of *Bruckmannia* (Stur), and to be preserved in such a manner, that it has to be considered as branches of *Calamites*, preserved on the same slab of shale.

The conclusions to which Mr. Stur arrived are that *Sphenophyllum* is no peculiar genus; but belongs to *Asterophyllites*, and both *Asterophyllites* and *Sphenophyllum* are branches of *Calamites*.

Professor Williamson and Professor E. Weiss have published their opinions about this remarkable discovery.[1]

Professor Williamson considers the connection of a *Sphenophyllum* and *Asterophyllites* as quite probable, and finds in it the confirmation of his own views on the relation of *Asterophyllites* and *Sphenophyllum*; but he thinks it impossible that both these genera should be the branches of a *Calamites* of the ordinary type, as it occurs in England, the structure of *Asterophyllites* and *Sphenophyllum* being totally different from that of *Calamites*.

Professor Weiss concurs with Professor Williamson as regards the impossibility of *Asterophyllites* and *Sphenophyllum* belonging to *Calamites*; but he is not prepared to accept the view that all *Asterophyllites* and *Sphenophyllum* should be closely related, and he finds a distinguishing character in the fructification. He says (*l. c.*), p. 264:—

"From the admission that branches with the appearance of *Asterophyllites* and *Sphenophyllum* may be found on the same plant, as observed by Stur, it would not at all follow that *Asterophyllites* in general is identical with *Sphenophyllum*, and still less that both these should be identical with *Calamites*."

Professor Weiss therefore seems to allow that *Asterophyllites*-like branches may be found with *Sphenophyllum*-like branches on the same plant, there being also two other genera, *i.e.*, *Cingularia* and *Bowmanites*, which have *Asterophyllites*-like stalks. *Sphenophyllum* and *Asterophyllites* of the carboniferous formation also agree in the arrangement of the leaves, all being arranged in whorls. But still he maintains the independence of *Sphenophyllum* in other cases.

If we now turn to the Equisetaceous plants in the Indian coal-beds, we find especially three forms—

Phyllotheca (not very frequent, and in the Raniganj group only).

Schizoneura (rare in the Barakar group, but very numerous in the Raniganj group).

Trizygia (in both the Barakar and Raniganj groups).

Besides these many other stalks, without certain affinities.

The genus *Phyllotheca* is known from the lower (palæozoic) coal-beds, the Newcastle beds and Wianamatta beds in New South Wales, and from the upper mesozoic beds (Bellarine-beds) in Victoria; from jurassic-beds in Siberia (Altai, Lower Tungutska river[2] and Eastern Siberia), and in Italy.

[1] N. Jahrb. f. Min., 1879, pp. 256 and 260.

[2] The formation with fossil plants in these two districts is jurassic, according to the last communication of Prof. Schmalhausen (Bull. d. l'Acad. des Sc. d. St. Petersbourg, Vol. XI, pp. 77-81), containing *Phyllotheca, Sphenopt. anthriscifolia, Asplenium whitbiense,* var. tenue, *Zamites inflexus, Podozamites eichwaldi, Ctenophyllum, Rhiptozamites* (Nöggerathia), *Czekanowskia rigida, &c.*

There is no representative of this fossil plant in the carboniferous beds of Europe, the leaves being joined to an undivided spathe at their base, and free in the upper part.

As regards the other two, *Schizoneura* and *Trizygia*, I find the following remark about them in Grand'-Eury's great work on the carboniferous flora in France,[1] page 404:—

"Il faut cependant bien reconnaître que certaines plantes des terrains secondaires inférieurs ont des attaches avec celles des terrains primaires ... . . le *Trizygia speciosa* de Royle, ressemble à un *Sphenophyllum oblongifolium* qui deviendrait beacoup plus ample; les *Schizoneura* du grès bigarré y suppléeraient aux *Asterophyllites*."

As far as *Schizoneura* is concerned, this thesis seems probable, this genus also having linear leaves, in whorls, which are however in most of the cases joined to two broader, encircling leaves, which morphologically originated from a spathe (sheath), to which all the leaves are joined in the beginning of the growth of the plant.

With *Trizygia* we will have to admit a slight modification. *Trizygia* was first proposed by Royle on account of the arrangement of the leaves, always six in three pairs on one side of the joints; this character is completely constant in all the specimens hitherto observed; the species was *Triz. speciosa*.

Mc'Clelland (1850) described it as *Sphenophyllum speciosum;* Unger (1850) as *Sphenophyllum trizygia.*

I myself followed Unger's example in my first notices on the Damuda flora (1876); but after these various researches on the nature of the carboniferous *Equisetaceæ*, I would return to Royle's original denomination, *i. e.*, *Trizygia*.

From the preceding notes on the genus *Asterophyllites* and *Sphenophyllum*, it would appear that some forms of these two genera may belong to the same plant, but in some other cases *Sphenophyllum* is an independent genus.

In the Indian coal-fields the form *Trizygia*, said to be representative of the carboniferous *Sphenophyllum*, is not associated with any *Asterophyllites*, there being no true *Asterophyllites* found; nor can it belong to *Schizoneura*, which to some extent can be considered as representing the *Asterophyllites;* for amongst the very numerous specimens of *Schizoneura* from the Indian coal-beds, not one specimen was observed which would show that the *Trizygia* might in some way be connected with *Schizoneura*, in the Talchir coal-field there is *Trizygia* without *Schizoneura*, and in the European Trias, where *Schizoneura* occurs, no trace of any form of the kind of *Trizygia*, or any *Sphenophyllum*, has hitherto been detected. *Trizygia* can therefore very well be considered an independent genus, having no connection with *Schizoneura*, as those forms of *Sphenophyllum* which have no connection with *Asterophyllites;* but I also think *Trizygia* will have to be considered as differing from the true *Sphenophyllum*.

In this latter the leaves are arranged in complete whorls round the joints, and the stalk is pretty thick, so that we have to consider it as an erect plant, growing

[1] Flore carbonifère du Dptmt. de la Loire et du Centre de la France, 1877

above the surface of water, like *Asterophyllites.* In the Indian plant, however, the leaf whorls are incomplete, there being always only six leaves, on one side of the joint, arranged in three pairs; the stalks are thin in comparison with the size of the leaves, showing perhaps that the *Trizygia* was a plant which floated on the surface of water.

In my paper on some fossil plants from Raniganj,[1] although placing the Indian form with *Sphenophyllum,* I pointed out all these differences, and distinguished two groups of *Sphenophyllum.*

At present I would formulate my view in the following manner:—

EQUISETACEÆ.

CALAMARIEÆ

Group: *Sphenophylloideæ.*

a.—Leaf whorls complete round the joint: number of leaves variable; leaves of the same size and shape in the same whorl

The true carboniferous *Sphenophyllum.*

b.—Whorls incomplete on one side of the joints; number of leaves six, arranged in three pairs, of which each differs from the other in size and partly also in shape of the leaves.

The *Trizygia* of the Indian coal-beds.

In this sense *Trizygia* may be considered as representative of the carboniferous *Sphenophyllum,* but is an independent genus.

We have therefore—

Phyllotheca, representing in the fossil flora the living *Equisetum.*

Schizoneura, representing perhaps the genus *Asterophyllites* of the palæozoic formation.

Trizygia, representing the genus *Sphenophyllum,* although differing from it.

ON MYSORIN AND ATACAMITE FROM THE NELLORE DISTRICT, *by* F. R. MALLET, F. G. S., *Geological Survey of India*

Mysorin.—The occurrence of copper in the District of Nellore, as well as in other adjacent parts of the country, appears to have been first brought to the notice of Government by Dr. Benjamin Heyne in the early part of the present century. In his "Tracts on India," published in 1814, an account is given of the rocks in the metalliferous region, and some details as to the nature of the ore. But the working of the mines, which appears to have been carried on extensively at an earlier period, was in abeyance at the time of Dr. Heyne's explorations, so that he was unable to obtain any reliable information as to the mode of occurrence of the ore, or its quantity. He was led, however, to suppose that the amount

[1] Jour. As Soc., Bengal, 1876, p. 312.

was very considerable, and that the working of the mines "had not been given up for want of ore, but from the jealousy of the Rajahs, who wished to hide such a treasure as long as possible from their superiors." Specimens of copper ore were obtained by Dr. Heyne, from near the surface, in several localities. Most of it was "malachite and mountain green," but there was also a dark-colored ore, intimately associated with the above, a sample of which was sent to London, and analysed by Dr. Thomas Thomson. His results were published in the Philosophical Transactions for 1814, and were reprinted as an appendix to Dr. Heyne's work above referred to. Dr. Thomson described the ore as follows:—"All the specimens of this ore which I have seen are amorphous; so that, as far as is known at present, it never occurs crystallized. Quartz crystals indeed are imbedded in it abundantly and very irregularly Sometimes they are single, sometimes they constitute the lining of small cavities to be found in it. These crystals are all translucent. In some rare cases they are colorless; but by far the greater number of them are tinged of a yellowish-red, and some few of them are green. The mineral is likewise interspersed with small specks of malachite; and with dark, brownish-red, soft particles, which I found to consist of red oxide of iron.

"The color varies in consequence of the irregular distribution of these extraneous substances. One specimen, which was the most free from the malachite and the red particles, was of a dark blackish-brown color. But in general the color is a mixture of green, red, and brown; sometimes one and sometimes another prevailing. Small green veins of malachite likewise traverse it in different directions.

"The fracture is small conchoidal, and in some parts of the mineral there is a tendency to a foliated fracture. The lustre is glimmering, owing, I conceive, to the minute quartz crystals scattered through it. The kind of lustre is resinous; and on that account and the varieties of colors, this ore has a good deal of the aspect of serpentine.

"It is soft, being easily scratched by the knife.[1] It is sectile. The streak reddish-brown. The specific gravity 2 620.

"It effervesces in acids and dissolves, letting fall a red powder. The solution is green or blue, according to the acid, indicating that it consists chiefly of copper."

The result of Dr. Thomson's analysis was as follows:—

Carbonic acid	16·70
Peroxide of copper	60·75
Peroxide of iron	19 50
Silica	2·10
Loss	·95
	100 00

The oxide of iron and silica he regarded as mechanically mixed, and he therefore considered the ore to be an anhydrous carbonate of copper, and a new

[1] The hardness is given as 4·25 in Dr. Thomson's Mineralogy of 1836.

mineral species. It is described (in an abridged form from the abovementioned paper) in his Outlines of Mineralogy (7th edition, 1836) as anhydrous dicarbonate of copper. In most works on mineralogy, of a date subsequent to Dr. Thomson's, the ore is alluded to as a doubtful species under the name of mysorin.[1]

With reference to the locality in which the mysorin was found, Dr. Heyne wrote: "Malachite and mountain green probably constitute the great mass of the ore in the copper veins, but an immense nest of the anhydrous carbonate of copper was found at Ganypittah, a village belonging to a Jaghierdor in the Venkatygherry district, about 40 miles west of Ongole. It exists there in a rock of the nature of gneiss, but considerably disintegrated, and the quantity of it must be immense, as forty coolies' loads were procured by a little digging, and sent to Mr. Travers, the Collector of the district, and almost as much remained which had been dug out, but which was not carried away."[2]

The village of Ganypittah—spelt Guramanypenta by Dr. Heyne in a pamphlet subsequently published by him, Gurumanipenta by Lieutenant Newbold, and Gunnypentah on the Atlas sheet—is 48 miles south-west of Ongole. From the bearings of the village from Nellore and Cuddapah given by Dr. Heyne, as well as from allusions to other villages in the vicinity, it is perfectly clear that *west* was a mere slip of the pen on his part.[3]

Amongst the specimens which were forwarded to the Geological Museum in 1873, for incorporation in the series illustrating the mineral resources of India, which was sent to the Vienna exhibition, was a parcel of perhaps a hundredweight, or more, of copper ore from "Gudisa Gundla near Ganmanipenta and Yerripali, Nellore District." Yerripali is a village about four miles from Ganmanipenta. A portion of the ore was reserved for the Geological Museum,

[1] From Mysore. The country, however, in which it was found, lies considerably to the east of the Mysore territory of the present day.

[2] In the fourth volume of the Journal of the Asiatic Society of Bengal (1835), there is a paper by Mr. James Prinsep, giving the results of his analyses of three samples of copper ore from the Nellore District. The analysis of one of these, which Mr. Prinsep thought might be the same ore as that examined by Dr. Thomson, is as follows:—

Hydrated carbonate of copper ...	68·5
Sulphuret of copper ...	0·[illegible]
Sulphuret of iron ...	12·4
Oxide of iron, silex, &c. ...	25·1
	100·0

It is, however, alluded to by Mr. Prinsep himself as an imperfect analysis. The third ore examined was sulphide of copper (63·0 per cent.) mixed with hydrated carbonate (31·7 per cent.) and some oxide of iron and silex. In the same paper there is an extract from a pamphlet, published by Dr. Heyne subsequent to the issue of his 'Tracts on India,' in which he describes the appearance of an ore which he considered to be of the same kind as that previously forwarded to Dr. Thomson, but as it seems clear that Mr. Prinsep was right in believing that Dr. Heyne had mistaken the sulphide with carbonate for the mysorin, it is unnecessary to quote the description.

The copper bearing localities of Nellore and the neighbouring country have been further described by Lieutenant Newbold in volume VII of the Journal of the Royal Asiatic Society.

[3] Journ. As. Soc. Bengal, Vol. IV, p. 575.

and while arranging the copper ores in the economic collection some time ago, I was struck with the outward resemblance of part of the Nellore ore to the Mysorin as described by Dr. Thomson. It is, however, only recently that I have had the opportunity of making a complete examination of it.

The ore, as sent, occurs in irregular broken pieces of various sizes up to about three inches diameter. It is a most heterogeneous mixture, made up of over half a dozen different minerals, some of which are, however, much more abundant than others. Taken roughly in the order of their relative abundance, there are visible to the naked eye, or with a lens:—

The dark reddish brown ore in question
Malachite.
Chrysocolla.
Quartz.
Yellowish-brown ochre.
Chalcocite.
Calcite.
Bornite.[1]

Pieces of pure malachite are not to be found, the mineral being greatly mixed up with chrysocolla and other minerals. Some portions of it, owing to disseminated reddish-brown specks, and specks of chalcocite, have a dark tinge. The chrysocolla, which is green and greenish-blue in colour, occurs both mixed with the malachite, &c., and in the form of thin seams, and as the linings of small cavities. The quartz is crystalline and generally colorless or nearly so, but it appears to have a green or yellowish colour from being imbedded in malachite or chrysocolla or ochre, or from having such running through it in thin seams. The proportion of chalcocite is quite small, but occasionally a tolerably pure mass an eighth of an inch long, or more, may be observed, and it can be seen scattered through many pieces of the ore with the aid of a lens. Calcite is a rare mineral only observed on a few specimens in the form of very thin seams. Bornite is extremely uncommon: only a very few specks have been detected. Some pieces of the ore consist mainly of malachite and chrysocolla, others mainly of the dark-coloured ore.

The most homogeneous portions of the latter have to the naked eye a dark reddish-brown colour, but viewed with a lens they are seen to be finely mottled in dark brownish-red and green. A thin section, which to the naked eye has a reddish-brown colour by reflected light, when viewed with a lens by transmitted light, shows this mottled structure still more plainly. The relative proportion of the two colours varies greatly. Occasionally a patch is found in which the green is almost absent. It is but rarely that one finds a surface of a quarter of an inch square that is not intersected by thin green seams of malachite and chrysocolla, which traverse the ore in different directions. Specks of chalcocite are also visible, and, very occasionally, those of bornite. The ore contains a few small cavities, partially filled with red ochreous oxide of iron.

[1] Besides these there are visible in a few specimens, which include some of the gangue-stone, hornblende, garnet, mica, &c., the matrix of the ore being, according to Lieutenant Newbold, mica- and hornblende-schist.

The lustre may be described as dull to the naked eye, but glimmering under the lens. Fracture imperfect conchoidal. On scratching the ore with a knife the streak is seen to vary in colour owing to the mottled character of the substance. Generally it is greenish and brownish-yellow. In the patches which are free from green it is brownish-red. The fragments which I selected for analysis yielded a bu..sh-gray powder. Hardness of the ore about 4·0. Specific gravity 3·80 . It effervesces with cold dilute acid, yielding a green or blue solution and leaving a red powder undissolved. On heating this powder with strong hydrochloric acid, ferric oxide is dissolved, and a white powder remains.

On comparing the description Dr. Thomson has recorded of the ore analysed by him with that just given of the ore I have examined, and recollecting that Dr. Heyne has stated that the mysorin occurs in an immense nest at Gannypentah, and that the ore examined by me was sent as the ordinary ore of the same locality, I do not think there is much room for doubt as to Dr. Thomson's ore and mine being the same. The only discrepancy of importance so far is in the specific gravity. Dr. Thomson found it to be 2·62, I 3·80. It may be observed on this point that it seems remarkable that while malachite has a specific gravity of 3·7—4·0, the corresponding anhydrous carbonate should have as low a specific gravity as 2·62. The low specific gravity can scarcely be ascribed to impurity, as Dr. Thomson's analysis shows this to consist almost entirely of ferric oxide.

In the crucial point however—the presence or absence of water—my analysis differs fundamentally from Dr. Thomson's. The fragments selected for analysis showed under the lens the brownish-red and green mottling alluded to above. Minute veins of malachite and chrysocolla were also visible, as well as specks of chalcocite, it being found impossible to obtain a sufficiency of the substance free from such admixture. Minute quantities of barite and probably calcite were also present, although they were not detected by the eye. The result of my analysis of the ore (dried at 100° C.) was as follows:—

Copper equiv. to ·56 of S.	2·22
Copper calculated as cupric oxide	61·46
Ferric oxide (with tr. of Al_2O_3)	6·74
Lime	·26
Baryta	·55
Carbonic acid	15·18
Silicic acid	4·39
Phosphoric acid	tr.
Sulphuric acid	·29
Sulphur	·56
Water [1]	9·02
	100·67

The barium sulphate was included in the residue insoluble in aqua regia,[2] together with the bulk of the silica, which was entirely soluble in alkali. The sulphur was clearly derived from the chalcocite. The ferric oxide was evidently

[1] The amount of water was determined by direct weighment.

[2] Also in the residue insoluble in hydrochloric acid.

mechanically mixed, being left (with silica, &c.) as a red powder when the mineral was treated with dilute acid.

It was not found possible to isolate sufficient chrysocolla in a pure state from the ore to make a separate analysis of it. Adopting, however, the normal composition of the mineral, the above figures would be equivalent to—

		Cu.	CuO.	Fe_2O_3	CaO.	BaO	CO_2	SiO_2	SO_3	S	H_2O
Malachite	77·03	...	55·65				14·98		...		6·39
Calcite	·46		...		·26		·20	...			
Chrysocolla ...	12·83	...	5·81					4·39			2·63
Barite ..	·84	..				·55		..	·29		
Chalcocite ..	2·78	2·22						...		·56	
Ferric oxide	6·74			6·74							...
	100·67	2·22	61·46	6·74	·26	·55	15·18	4·39	·29	·56	9·02

After deducting the cupric oxide and water equivalent to the silica, and the carbonic acid equivalent to the lime, there remains a residue of, water 6·39, carbonic acid 14·98, cupric oxide 55·65; quantities which have the oxygen ratio of 1 : 1·92 . 1·97; the oxygen ratio in typical malachite being 1 : 2 : 2. It is clear, therefore, that the ore is an impure malachite owing its dark colour to admixture with ferric oxide and chalcocite. Some specimens, indeed, of the Gannypentah ore, which are seen to be impure malachite by the eye, have a dark colour owing to a smaller admixture of the same kind.

It is not certain that the lime exists as calcite, but it is probable, calcite having, as before remarked, been found in some specimens of the ore. The point is, however, of no importance with reference to the main question. Thus, if the lime be included with the chrysocolla, the above-mentioned ratio will be 1 : 1·94 : 1·99.

I have alluded to small portions of the mysorin in which, when viewed with a lens, green is almost absent. Fragments of such, when dropped into dilute acid, give merely a minute bubble or two of carbonic acid; the liquid is faintly tinged with green, and the fragment remains almost unacted on. When heated with strong hydrochloric acid, iron is abundantly dissolved. Such portions of the ore are in fact merely ochreous ferric oxide. The amount of effervescence increases with the amount of green visible in the specimens experimented on.

Atacamite.—Amongst the specimens of copper ore from the Nellore district in the Museum, there is a mass of chalcocite, which appears to have been originally obtained by Mr. Kerr, a gentleman who endeavoured, but unsuccessfully, to work the mines about the year 1835. The specimen weighs about six pounds, and evidently formed a portion of an irregular vein, two or three inches thick. It contains a few disseminated crystals of magnetite, and is intersected by small, irregular seams containing (with some malachite) dark emerald green, translucent, crystals, which, on examination, proved to be atacamite. The point is worth notice, in that the locality in question is, I believe, the only one in which atacamite is known to occur in India.

ON CORUNDUM FROM THE KHÁSI HILLS, BY F. R. MALLET, F. G. S., *Geological Survey of India.*

Amongst the specimens lately transferred from the Economic to the Geological Museum, was one of "hone stone", locally known as "maushynrut", from the Khási Hills. Its high specific gravity attracted my attention, and on examination it proved to be corundum. It is a finely granular, light gray, or grayish-white rock, containing microscopically minute specks of a translucent, dark red, mineral. It scratches topaz with ease. The specific gravity is 3·93. It appears from information obtained by Colonel Sherer, Deputy Commissioner of the Khási and Jaintia Hills, to whom the matter was referred, that the mineral is procured at a village called Nongryniew "towards the north-west of, and at a distance of about two days' journey from Nongstoin." Nongstoin is the capital of a petty Khási state; latitude 25° 31′ longitude 91° 20′. It would seem that there are no quarries of the stone, but that the villagers pick up pieces found loose on the surface, and use it locally, as before mentioned, for hone or rather grind-stones.

As the edge of the hills to the north-west of Nongstoin is about 30 miles from that place, and within 15 miles of the Brahmaputra, it would appear that the locality where the corundum is found cannot be very far from the edge of the hills, and that it is within a day or two's journey from the river, for carts or laden animals. If, therefore, the stone occurs in large quantity—a point respecting which no information is available—it is worth attention commercially. Corundum is found in large quantity in South Rewah,[1] and notwithstanding the fact that it is more than a hundred miles from the railway, over a road of which the first third is execrable even for laden cattle, and impassable for carts, the corundum is exported to some extent to Mirzapur. The Khási stone, therefore, if found near the edge of the plains, would be far more advantageously situated with respect to carriage. The Rewah corundum is a tougher, less easily pulverized stone than the Khási. Whether the powder of the latter, however, would do the same amount of work as that of the Rewah, is open, perhaps, to question. We are indebted to Colonel Sherer for a specimen of the corundum lately received, weighing about 20 pounds and measuring about 4 × 7 × 9 inches. It had evidently been in use as a grindstone.

[1] Records, Vol. V, 20, Vol. VI, 43.

NOTE ON THE JOGA NEIGHBOURHOOD AND OLD MINES ON THE NERBUDDA, *by* G. J. NICHOLLS, C. S., *Officiating Commissioner of Excise, Central Provinces.*

In the tract of country between the Great Indian Peninsula Railway, the Chota Táwa (which divides the Nimár and Hoshangabád districts), the Nerbudda and the Ganjál river, most of the western area is composed of metamorphics and Bijáwars, and these in the eastern area pass under alluvium.

Granitic and syenitic rocks show at Harda in the river bed. These rapidly pass into gneiss as we go north-west towards Handia. The gneiss soon passes under cherty bands and quartzose breccia. Due north from Harda about seven miles, and to the east of the road to Handia, the streams lay open beds of much disintegrated granitoid or gneissic rock which would probably yield kaolin.

Between two and three miles south of Handia small hills, with a westerly run, are met, composed of a peculiar quartzite belonging to the Bijáwar series.

At Handia the bed of the Nerbudda is of granite, the felspar being of a marked red colour. Across the river at Nimáwar, the quartzites again come in.

From Harda to the south-west, granites are found till the Máchak valley is met near Mandla. Further down the railway line trap comes in, a softish red or reddish purple stone, easily cut and used for bridge work.

Down the Máchak which runs in a north-west direction at Dhanwára, a coarsely crystallized protogene rock forms the bed of the stream.

At Deopur a limestone has been quarried to a considerable extent.[1]

Westward of this, through Gambir to the Chota Táwa, there is much schist and gneiss, with trap outliers superimposed. Going due west of Harda to Sontalai, I quickly left the granite and syenite and passed beyond the gneiss. From this to Sontalai, bands of yellowish brown chert and outcrops of a highly silicious limestone (Bijáwar) alternate in a most confused manner. Where there are hills, as at Niljhar, they are mostly of quartzite with chert and jasper. The surface of the limestone is much weathered and gnarled, and the silicious layers stand out in relief, often assuming the half vitrified look of hornstone. Close to Sontalai, there is much ferruginous debris, probably from the numerous iron melting furnaces once worked on the western side of the village.

A curious conglomerate rather than breccia occurs in the stream west of the village. In the afternoon I went to the iron mine about two and a half miles from Sontalai near the Máchak river, seemingly a pocket of hæmatite and iron ochre it has been worked out to a depth which is below the present level of the water in the pit. About here, frequent and quick transitions take place from gneiss to schist and narrow greenstone or diorite bands, giving the appearance of inter-stratification. The position of these and of the schists is generally nearly vertical. Lumps of quartz and nodules of trap lie about on the ground, also a few agates and flints. From Sontalai to Joga across the Anjan, the trap and greenstone dykes, and metamorphic schists disappear. The elevations are almost entirely of quartzite, and the yellow-brown cherty jasper is much stronger. South of

[1] The specimens forwarded are of Lameta limestone, the same as that quarried at Jabalpur. H. B. M.

Joga Khurd, a strong course of Bijáwar grey weathered limestone strikes to cross the Nerbudda, which river here runs from north to south. The limestone course can be seen forming a reef across the bed of the Nerbudda, but not quite at right angles. The course is nearly north-east-by-east to south-west-by-west.

Between Joga Khurd and Joga Kalán, cherty or jasper breccia is very common, and almost seems to overlie the Bijáwar limestone. From Joga Khurd it is about half a mile to the excavations known all through the country as the "Chándi Khadán" (silver mine).[1]

The pits are in two parallel lines. The most northern line is apparently a continuous excavation of about half a mile in length on the Bijáwar limestone band. The depth and width vary greatly, and the direction runs pretty straight. These open excavations end about 250 yards from the banks of the Nerbudda; the line, I think, generally showed some elevation as compared with the ground on either side. The depth may be generally about 25 feet, and the breadth 15 feet. About 250 yards south of this line of excavation is the second line of excavations; these are generally much narrower and much deeper, much more like evidences of sinking on a lode. Here generally there was a determined dip of about 80° to the north, the strike being as described where the limestone reefs cross the Nerbudda. Where the limestone ridge comes to the surface, the weathered appearance of the rock is remarkably wild and weird. The excavations are not all in one line or continuous. Apparently parallel and intersecting lodes or leaders have been followed.

The length of these excavations was less than that of the northern run. In some places from ten to twelve feet in width appear to have been dug out, but generally six feet would be the average. In some parts a considerable depth, about 40 feet, was attained; only in one pit is water found. This has a depth of 8 feet in a small pit or pocket at the extremity of the excavation, which elsewhere was about 30 feet deep. From this I took most of my specimens.

Although at the surface the rock is very contorted, and shows some sign of concentric formation and numerous silicious bands like hornstone, we soon got down into fairly settled ground. But at the bottom I saw a tendency to pockets, there being round holes or nests picked out by the old miners. From the depth where I was working, I could see nothing else to lead me to think that the lode went no deeper; but I had not the opportunity of testing this. From the specimens procured it will be seen that the limestone, through which probably a strong lode ran, is interspersed with mineral. This shows most frequently in the

[1] The reputation of the old pits at Joga as silver mines is certainly of no very recent invention. In March 1855 my attention was drawn to them by Captain Nembhard, then Assistant Commissioner at Hoshangabad. I found the mines just as described by Mr. Nicholls (there were then no maps of the ground); the deposit seemed to be so thoroughly worked out that I had some difficulty, with only a hammer, to make out what the ore was. A very much richer ore than any now visible was no doubt found in the old excavations, and it is quite possible that similar bunches may still lie to the deep of the old workings. The Karnpura iron ore, which is probably that referred to by Mr. Nicholls, occurs as a vein in the Bijáwar jasper-breccia. It is a rich red-hæmatite, though in places much mixed up with the jasper rock.

H. B. MEDLICOTT.

lines of jointing. It would look as if occasionally I have got fragments of leaders or strings belonging to a large lode. I saw no marks of blasting, or of the use of crowbars.

The country around is all forest, and the soil very poor. The Mowassi Kurku is almost the only inhabitant. He is superstitious and would never have been able to execute the mining work to be seen at Joga. This was probably done by the Patháns, who held the fortress at Joga Kalán, a building supposed to be of the time of Alamgir. Many other reasons besides exhaustion may have led to the abandonment of these works: for instance, inability to control the water in the lower levels, want of acquaintance with machinery for raising the ore with tools, and methods of blasting for breaking down the rock, or the fall of the Mogul power at Handia, and the succession of the Mowassi and Pindhári robber hordes. One cobra put to flight five workmen of mine. They considered him to be the guardian of the treasures In prospecting both this year and last, I had to use my rifle.

Possibly it might be worth while to spend a little money in trying to expose the lode or in driving cross-cuts Water power is probably available for stamping

NOTE.

The samples from the Joga mines, sent by Mr. Nicholls to the Geological Survey Office, were as follows :—

No. 1.—Dug by Mr. Nicholls from the remnant of the *gangul*, or pocket, near the bottom of the 'water pit'—gray dolomitic limestone, containing a few cherty layers . galena is very sparsely disseminated through both limestone and chert, and in one or two specimens, specks of copper pyrites were observed.

No. 2.—Dug out from side of the excavation of the 'cobra pit'—specimens similar to No 1.

No. 3.—Casing of a pocket in the 'water pit', dug out by Mr. Nicholls—ferruginous, manganiferous, dolomitic limestone with cherty bands; galena and copper pyrites disseminated as in No. 1.

No. 4.—From debris at surface of 'panther pit,'—gray dolomitic limestone with specks of galena.

No 5.—Casing from 'water pit,' dug out by Mr Nicholls—ferruginous, manganiferous, dolomitic limestone.

No. 6.—From debris of 'water pit' and 'hyæna pit'—same as No. 5. Some pieces are sufficiently ferruginous to be called spathic iron. Contains a few specks of galena.

Besides the above, a quantity, perhaps half a cwt., of stone was sent, taken from the debris of several workings. It was similar to the sample No. 1.

None of the above described samples showed any signs of the existence of a lode. The galena is very scantily disseminated through the limestone and chert themselves. The percentage of ore to gangue is extremely small, so much so that it was necessary to pulverize and wash several pounds of stone to obtain sufficient galena for an assay. The specimens sent are themselves useless as an ore, although of course indicating the possibility of galena occurring in larger quantity. As they were mostly taken from the mere debris of the mines, they cannot be regarded as fair samples of what the average ore formerly extracted was. To really test the value of the mines, it would be necessary to excavate sufficiently deep to penetrate beneath the old workings.

The lead extracted from the galena was found to contain 21 ounces of silver to the ton; a very fair proportion, but certainly not one which would entitle the mines to the name of 'silver mines,' rather than lead mines.

F. R. MALLET.

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MAPS.

Carta Geologica de Portugal (1876).

SEN CARLOS RIBEIRO.

June 30th, 1879.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1879. [November.

NOTE ON THE "ATTOCK SLATES" AND THEIR PROBABLE GEOLOGICAL POSITION, *by* DR. W. WAAGEN.

In the Records of the Geological Survey of India, Vol. XII, pt. 2, there is a paper by Mr. Wynne, entitled "Further notes on the geology of the Upper Punjab," which bears a special interest on account of the general views on the geology of that country. As many of the points treated of in the paper are yet to be considered as open questions, it seems not advisable to pronounce any opinion on them until further materials have been collected, but it may not be useless to notice some points which might be of value towards the elucidation of the questions discussed by Mr. Wynne.

There is before all the age of the "Attock slates." Mr. Wynne is quite right when he considers the evidence upon which the opinion of their being of silurian age is founded very scanty indeed; and only the absence of any other clue towards the determination of the age of those slates could at the time justify the opinion expressed in our joint memoir on Mount Sirban, that the occurrence of lower silurian fossils in gravels in the Kabul river, which lay approximately in the strike of the "Attock slates," would make a silurian age probable also for the latter.

It is very much to be regretted that to the careful search of Mr. Wynne the slates have proved absolutely unfossiliferous up to the present. Yet this sterility in fossils seems not to prevail at all localities. Among the materials which have been most liberally sent to me by the Geological Society of London, there are about a dozen specimens of a Spirifer, which bear, however, only the label "Punjab." These specimens are preserved in a black slate, which, if the specimens came really from the Punjab,—and there is no reason why this should be doubted,—must have belonged to the Attock slates, as there is no other rock known to me in that part of India which would bear similar petrographical characters, and from which the specimens could have come.

Though these fossils are more or less deformed by oblique pressure, yet the species can without difficulty be determined. All the specimens belong to one and the same species, and cannot be distinguished from *Spirifer keilhavi*, Buch., (*Sp. Rajah*, Salt.). As this species is one of those most characteristic of the carboniferous formation in the Himalaya, and as thus the determination of the age of the rocks from which these fossils came considerably differs from the age hitherto attributed to the Attock slates, it is necessary to be doubly cautious in accepting the current opinion regarding these slates.

The rock in which the fossils are preserved is, as stated above, a black, not very hard slate, such as I have seen to occur at many places in the Attock slates; but there are also outside of the Punjab some localities where similar slates occur. I have myself seen similar slates from the Milam pass which seem also to belong to the carboniferous formation, and seem to be there inferior to white limestones, also full of carboniferous fossils, the latter, however, of a much more recent type. Similar slates have been described by Lydekker from Eishmakam in Kashmir, whilst at other places in the same territory the carboniferous formation is composed nearly entirely of thick limestones. The slates of Eishmakam have been compared by Lydekker to the "Kiol group" and the limestones to the "Great limestone" of the outer Himalaya. Thus it might be very possible that in the Himalaya the carboniferous formation should present two sub-divisions, one older slaty, and one younger calcareous sub-division. This, however, does not prevent that at many localities the whole formation might be made up of massive limestones.

If, therefore, the fossils under consideration did not come from the Punjab, they might have come from several parts of the Himalaya. There is, however, no reason to doubt their coming from the Punjab. There exists in the Punjab a great amount of rocks perfectly similar in appearance to the rock in which the specimens occur, and if these rocks up to the present have proved apparently unfossiliferous, this does not exclude the possibility that there exist localities where fossils do occur. That all these fossils belong only to one species already goes far to prove that the slates containing them are not very rich in fossils. How much it depends on circumstances whether one does meet with certain fossils is also exemplified by the fact that I as well as Mr. Wynne have been searching in vain in the Salt-range for determinable plant remains, and yet there are several beautifully preserved plant remains from the Salt-range in the Geological Society's collection.

Thus we may fairly accept the indications of the label attached to these specimens of *Spirif. keilhavi* as correct; and from this it would follow, that the Attock slates will have to be considered in future as belonging very likely to the carboniferous period.

If we accept this view, one of Mr. Wynne's remarks becomes of special importance; this is that the limestones of Gandgarh remind one more or less of the great limestone of the Jamu hills. This would fit entirely into the state of things observed elsewhere, and the discrepancy, at least in the carboniferous formation, between Kashmir, Jamu, and Hazara would no longer be so striking as is supposed by Mr. Wynne. These limestones are entirely absent in the neighbourhood of Mount Sirban, and this absence possibly might account for the marked unconformity there between the Attock slates and the more recent formations.

But also for these latter the determination of the Attock slates as of carboniferous age would have a deciding influence, as then the geological horizon they occupy might approximately be fixed. In the little memoir on Mount Sirban, Mr. Wynne and I have distinguished a group of rocks as "Below the Trias," consisting chiefly of cherty dolomite, to which are subordinate red sandstones and quartzites. We have separated these rocks from the Trias for the simple reason that there existed no proof of any kind that they belonged to that formation, and as we then considered the Attock slates as of silurian age, the number of formations to which those strata "Below the Trias" could have been assigned, was so very large, that it seemed only prudent not to express any definite opinion as to their age. Now the case is quite different: these beds would rest unconformably on the carboniferous Attock slates, and be succeeded conformably by upper triassic or rhætic strata; thus it becomes very probable that the strata "Below the Trias" represent the Lower Trias, *viz.*, Muschelkalk and Buntsandstein formations.

In his more recent memoirs Mr. Wynne introduces the designation of "Infra-triassic group" for these strata, and most recently he considers this group as identical with his "Tanol series," which is extensively developed in the northern part of Hazara; but such a homotaxis can hardly be maintained. Wynne's "Infra-triassic group," or the group "Below the Trias" of our joint memoir on Mount Sirban, consists chiefly of cherty dolomites, and exhibits sandstones and quartzites in a subordinate manner only, whilst according to the sections published by Mr. Wynne, the Tanol series consists chiefly of slates, sandstones, and quartzites, to which the dolomitic limestones are subordinate.

Besides this the thickness of the group "Below the Trias" and that of the Tanols is so enormously different that a comparison between the two is barely possible.

The only formation to which the Tanol series seems to bear some resemblance is the silurian of the more central parts of the Himalaya (Milam pass, Niti pass), where the fossiliferous beds consist also of white sandstones.

The apparent superposition of these Tanol rocks over the carboniferous Attock slates can be no reason for the rejection of such a parallelisation. Before it is possible to accept Wynne's view that the Tanols are more recent than the Attock slates, and pass upwards into the gneiss which composes the central Himalayan chains, much stronger proofs, stratigraphical as well as palæontological, than those published in his memoir must be adduced; and until decisive materials are available, it will be much more prudent to consider the whole silurian Tanol series as overthrown and faulted against the Attock slates. Then the riddles of the geology of Hazara will easily be solved.

ON A MARGINAL BONE OF AN UNDESCRIBED TORTOISE, FROM THE UPPER SIWALIKS, NEAR NILA, IN THE POTWAR, PUNJAB, *by* W. THEOBALD, *Geological Survey of India.*

The bone which forms the subject of the present remarks, and of which a figure of the natural size is given, is remarkable for exhibiting a structural adaptation which exists in no living species, and, so far as I am aware, has not yet been described in any fossil. It will be necessary, therefore, to refer it to a new genus which I propose to associate with the name of the illustrious fellow-worker of Falconer, Colonel Cautley, and characterize as follows:—

CAUTLEYA.

Genus *Emydinorum*, novum, in quo sternum, et thorax, et ossa marginalia, suturâ tripartitâ cartilagineâ junguntur, sectionem morsum hirudinis simulantem monstrante.

The above character suffices to demonstrate the distinctness of the species under consideration from any previously described, and the specific designation is derived from the most prominent character of the animal as yet known, and in the annular arrangement of the marginal bones.

C. ANNULIGER, n. s.

The marginal bone, whereon I base the above genus and species (and which, except a slight fracture at one corner, is perfect), is trapezoidal in shape and cuneiform in section. It presents an upper and under surface, respectively slightly concave and convex, which were shown to have been external surfaces by the clearly marked furrow which traverses them, and indicates the junction of the superficial or dermal scutes (fig. 1, *a b*, fig. 2, *c d*). The bone is bounded laterally by a jagged sutural surface, whereby a complete and rigid bony union was effected between it and the adjoining marginals, which must have constituted an encircling bony ring of an extremely rigid character, from the great horizontal breadth of the bones in question. The peculiar and characteristic feature, however, of the bone lies in its internal margin (fig. 3, *e f g*) which displays a smooth surface, indicating a cartilaginous union only, with the bones of the sternum and thorax. This inner marginal surface is obscurely divided into two areas of unequal breadth, of which the lower is broader and opposed to the sternal plate, whilst the upper and narrower surface receives the thrust of the bones of the thorax. The therax and sternum were no doubt united by a cartilaginous suture, as a cartilaginous junction with the marginal is opposed to the idea of a rigid bony union between the bones in immediate contact with them, since a rigidly anchylosed bony ring united only by cartilage to bones themselves joined by a bony suture, could lend no additional strength, though it undoubtedly would do so supposing it to cover and defend a cartilaginous union of the sternal and thoracal bones.

The length of the external margin is 5·5 inches, which indicates approximately an animal close on 10 feet in circumference. The condition of the suture shows that the individual was not of full age, and 12 or 14 feet may probably be assumed as not an over estimate of the dimensions of the fully adult animal, which probably exceeded the dimensions of the largest *Chitra*, though our positive knowledge of the precise limits attained by our living Chelonian is singularly meagre and limited. That *Cautleya* was an aquatic species may be inferred from the cartilaginous union of the bones of its case, which in living species is seen in such fluviatile forms as *Cuora* and *Cyclemys* and is unknown in terrestrial forms. The opposite conclusion, however, among Chelonia cannot be drawn from the complete ossification of the body case, as *Batagur* and its allies are possessed of as completely ossified a case, though strictly aquatic, as *Testudo*, which is entirely terrestrial.

The specimen was obtained near Nila, on the Sohan river, in the Rawalpindi district, in upper Siwalik strata, and in company with remains of *Mastodon perimensis*, F. et C., *M. pandionis*, F., *Palæopithecus sivalensis*, Lyd., *Acerrotherium perimense*, F. et C., and other Siwalik fossils.

Among the collection from the same locality are fragments of a large Testudine, exceeding in size the living *Manouria*. They consist of one anchylosed pair of episternal bones, with a transverse diameter of 8·5 inches (allowing for a slight fracture); a single right episternal bone of a rather larger size, 2·5 inches thick and 6·25 long, and a free marginal (that is, one anchylosed to the thorax only) 3·3 broad and 4·5 long (measuring from the outer margin).

These bones would indicate an animal nearly as large as the last, and probably fully equal to it in bulk. At present, however (with no other materials), it seems undesirable to give it a name.

SKETCH OF THE GEOLOGY OF NORTH ARCOT DISTRICT, *by* R. BRUCE FOOTE, F.G.S., *Geological Survey of India.*

Topography.

The North Arcot District, one of the purely inland districts of the Madras Presidency, is topographically characterized by its great irregularity of surface. Except in its south-eastern quarter, the district is extremely hilly and in some parts quite mountainous. In the west and north-west it embraces a considerable part of the high and rugged eastern scarp of the great Mysore plateau, from which many long spurs jut out far to the eastward. In the south-west it includes the northern end of the Javádi mountains and the Vellore hills. In the north it includes the well known Tripatti mountains, the "sacred hills of Trippetty," and the southern extremity of the Vellakonda (Eastern Ghâts so-called). The north-eastern corner of the district contains the Nagari mountains; and three groups of lower hills, the Sattavedu, Alikur, and Naikenpalem hills, on the extreme eastern border of the district, and a considerable number of detached hills in the gneissic country west of the Madras railway. Some of these latter, as the Maddur (Muddoor), Sholinghur, and Makrs Drúg hills, and others, are of considerable height and extent. In the south-east of the district only two detached hills need be named, those of Wandiwash and Chitpat (Chittapett).

Hydrology.

The hydrology of the district is very simple, all the drainage falling into the Bay of Bengal and chiefly by the Pálár river, which, rising on the Mysore plateau, drains the whole southern half and greater part of the centre and west of the district. The north-eastern part feeds the Korteliar and Nagari (Naggery) rivers, and also the Narnavaram and Suvarnamukhi (Soornamookey).

Formations.

The geological formations met with in this district may be conveniently classified into six groups, which may be arranged in their true order of superposition as follows :—

RECENT AND POST-TERTIARY.	6.	Soils and subaerial deposits
	5.	Alluvial deposits ; fluviatile.
	4.	Lateritic sands, gravels, and conglomerates.
MESOZOIC ...	3.	Upper Gondwána series, Rajmahal or "plant" beds.
AZOIC ...	2.	Kadapa series.
	1.	Gneissic series, with intrusive trappean and granitic rocks.

General distribution of the rocks.

The gneissic series, which forms the basement on which rest all the other rocks, occupies by far the larger part of the whole area of the district, and it is only in the north-eastern and eastern parts that younger rocks occur. The gneissic rocks include all the western part of the district, and form the rugged eastern scarp of the Mysore plateau already referred to (p. 187). Eastward of the plateau, are numerous spurs stretching away from it, and eastward of these again are numerous clusters of detached hills, some of considerable size and elevation, and remarkable for their bold forms and great ruggedness. These occupy the gneiss area up to the very convenient geographical line formed by the north-west line of the Madras railway, eastward of which the gneissic rocks soon disappear under newer formations, to be referred to separately further on. The gneissic area south of the Pálár shows the northern end of the Javádi mountains and the hills east and south-east of Vellore. Further to the south-east the gneiss area becomes comparatively flat, and no hills of any importance rise from its surface, the two hills of Wandiwash and Chitpat (Chittapett) excepted, which have already been named.

Gneissic series.

Kadapa series.

Returning to the north of the Pálár, the gneissic rocks are overlaid by great masses of quartzite and conglomerate belonging to the Kadapa series, which form the greater part of the detached mountains collectively known as the Nagari mountains. The south end of the Vellakonda and the sacred hills of Tripatti to the north are also formed of rocks belonging to the same sub-division of the Kadapa series.

The tremendous lines of scarp and often vertical cliffs surrounding in many parts the Nagari and Tripatti mountains give a peculiar and grand character to the local landscape.

Upper Gondwána rocks.

South-eastward of the Nagari mountains lie the three hill groups before mentioned (p. 187), *viz.*, the Sattavedu, Alikur (Allcoor), and Naikenpalem hills, consisting of great beds of hard conglomerates and sandstones in the Sattavedu and the eastern half of the Alikur hills, and of uncompacted conglomerates, clays and shales in the western half of the Alikur hills and the Naikenpalem group. Some of these beds are fossiliferous, and the fossils show them to belong to the upper division of the great Gondwána system, which includes all the plant-bearing beds in the peninsular area. The fossils agree in many cases, specially with those found in the Rajmahal beds of Bengal.

South of the Naikenpalem hills are other outcrops of the "plant beds" lying between the Nagari river and the Kortelliar. South of these again and south also of the Pálár, the Upper Gondwánas re-appear in a considerable number of small patches dotted over the surface of the eastern part of the gneissic area in the Arcot taluq.

Lateritic rocks.

Much of the surface of the "plant beds" is masked by lateritic deposits, which overlap also in many places on to the gneiss. They do not cover much ground in North Arcot. One of the uppermost places in the superposition of the rocks, but the lowest in point of elevation over the sea level, is occupied by the alluvial formations, which are all fluviatile. Although of very limited extent, they yet offer some points of considerable interest.

Alluvial formations.

The soils are of no special interest, but among the subaerial deposits, the enormous masses of talus which surround the mountains in the north-eastern part of the district are remarkable.

Previous observers.

But very little had been written on the geology of North Arcot before it was taken up systematically by the officers of the Geological Survey Department. Dr. Buchanan and Dr. Benza had given short notes on the geology of the country along the Madras-Bangalore road between Arcot and the Mysore frontier, and Lieutenant (afterwards Colonel) Baird Smith, of the Engineers, had published a paper "on the crystalline structure of the trap dykes in sienite of Amboor," entering elaborately into the questions connected with the formation of such rocks.

The Geological Survey.

The geological survey of the district was taken up in 1863 and continued in the years 1864 and 1865, the work being undertaken by Mr. C. Æ. Oldham, Mr. W. King, and the author. About two-thirds of the district was surveyed, the greatest part being done by Mr. Oldham, who examined the south-eastern and central parts, while Mr. King surveyed the north-western corner. The eastern part north of the Pálár, and the Vellore and part of the Gudiattam (Goriattum) taluqs in the south-western corner of the district, were surveyed by the author.

The Chittur, Palamaner, part of the Gudiattam taluqs, and the Punganur zemindari, though not surveyed, were traversed in several directions by Mr. C. Æ. Oldham and the author, and sufficient is known of them to form an idea of their general geological features.

Its results how published.

Of the information gained by the geological survey part only has been hitherto published. So much of the eastern part of the district as lies within the eastern half of sheet 78 of the Indian Atlas has been illustrated in a geologically colored copy of that half sheet printed in 1872. The features of the northernmost part of the district, including the Tripatti and Nagari (Naggery) hills, were shown in the small-scale general map of the region occupied by the Kadapa and Karnul rocks, published with Mr. King's memoir on those rocks in 1872,[1] and the component rocks described in that memoir.

Of the country illustrated in the geological edition of sheet 78 (eastern half), only part has been described in any of the publications of the Geological Survey hitherto issued.

The part described included the south-eastern half of the Wallajah taluq, the eastern part of the Karvet Nagar zemindari, and the south-eastern part of the Calastri zemindari; the description of these was given in a Memoir by the author published in 1873.[2] Brief references to the three tracts just named and to the Nagari region had been published rather earlier by Mr. King and the author in two papers in the Records of the Geological Survey of India, under the respective titles, "On the Kuddapah and Kurnool Formations" (1869), and "Notes on the Geology of the neighbourhood of Madras" (1870). Some of the geological features of the North Arcot country were also referred to in a paper "On the occurrence of stone implements in the formations in various parts of the Madras and North Arcot districts," published in the Madras Journal of Literature and Science for 1866 by the author, with notes by Mr. King. The same and some other geological features of the North Arcot country were touched upon in another paper "On the distribution of stone implements in Southern India," read by the author before the Geological Society of London in 1868 and published in the Society's Journal for the same year.

The Memoir "On the Geology of parts of the Madras and North Arcot districts," &c.,[3] above quoted gave a rather full account of the Upper Gondwána and overlying lateritic rocks in the Arcot district, as also of the alluvial valleys of the Nagari and Narnavaram rivers. The information there given will be repeated in a somewhat condensed form in these pages, together with a good deal of new matter not yet published, owing partly to the non-completion of the survey of the district, but mainly to the premature decease of Mr. Charles Æ. Oldham.

The only geological map on which North Arcot had been represented on an intelligible scale prior to the publication of the geological edition of sheet 78 was Greenough's general geological sketch map of India, published in 1854, a laborious but in many respects untrustworthy compilation. The features of the North Arcot country are laid down very incorrectly in this map, the data from which it was compiled being utterly insufficient for the purpose.

The older rocks of the district being in great measure the source whence the materials for the formation of the newer ones were derived, it will be most convenient to describe the several groups recognized in their ascending order of sequence.

[1] Memoirs Geological Survey of India, Vol. VIII.

[2] Memoirs Geological Survey of India, Vol. X, pt. 1: "On the geology of parts of the Madras and North Arcot districts lying north of the Pálár river and included in sheet 78 of the Indian Atlas."

[3] Memoirs Geological Survey of India, Vol X, pt. 1.

GROUP I.—*The Metamorphic or Gneissic rocks.*

It has already been pointed out that the rocks belonging to this group occupy by far the greatest part of the whole district. The predominant varieties are the massive obscurely bedded ones known among geologists as granite-gneiss and syenite-gneiss. The well-bedded fine-grained schistose varieties are much less frequently met with than in other parts of the great gneissic region, as in the Trichinopoly, Salem, Madras, and Nellore districts, but they do appear locally among the coarse granitoid varieties, and occurrences of them will be described further on.

As in all the gneissic regions, the rocks show abundant signs of having been much disturbed, contorted and uptilted since their original deposition, and finally forced into series of great synclinal and anticlinal foldings, the edges of which may in some cases be easily traced along great distances.

Prevalent strike.

A study of the direction of the edges or outcrops of the beds, technically called the "strike" of the bedding, shows that in the south-eastern part of the district the beds have a strike from south-south-west to north-north-east, but as they are traced northward they are found to trend till they run north-south, which is the prevailing strike in the central parts of the district. If followed into the extreme northern part, they will be found to have trended to north-north-west. This change in the strike is part of a great curve formed by the metamorphic rocks in the latitude of Madras, and affecting the whole gneissic series eastward of the Mysore plateau.

In describing the general appearance of the central part of the district, Mr. Oldham in his notes remarks very aptly: "Speaking generally, the whole area might be said to be one of quartzo-felspathic gneiss, commonly syenitoid or granitoid." "When, however, I say quartzo-felspathic, I do not mean to imply that these minerals only constitute the rock, but that they preponderate largely, and that the hornblende and mica which also enter into its composition play a very subordinate part, except in occasional bands." These remarks apply equally well to the general features of the rugged flanks of the plateau edge as seen in the Sainegunta and Mugli Ghâts and at Satghur, and to the whole western part of the district in fact. They apply also fully to the gneiss of the eastern side of the district north of the Palár, but less so to the rocks of the south-eastern taluqs. Here and around Vellore the well bedded varieties are rather more largely developed, and they are much less largely quartzo-felspathic in constitution.

Commencing in the western part of the gneissic area, the eastern edge of the Mysore plateau consists mainly of coarse granitoid gneiss, which is well seen in the hills west of Ambur, at Satghur, and thence generally on the Sainegunta and Mugli Ghâts leading to Palamaner, all around that place and northward of it, very conspicuously in the Gam Kondas and other hills stretching away to Avulpilli Drug. The same description applies to the whole of the country between Vellore and Chittur, and to the very hilly tract lying between the Poiney river and the Madras railway. East of the railway too the granitoid gneiss extends under the younger Kadapa and Gondwána rock series.

In the southern part of the gneissic area, forming the northern end of the

Javádi mountains, are great bands of granitoid gneiss, some of them remarkable for their coarseness of texture, which is blotchy and often markedly porphyritic, *e. g.*, the rock forming the mass of the Palikonda (Policondah) mountain and of the Vániambádi[1] trigonometrical station hill, some three or four miles to the south-south-east. Similar "blotchy" gneiss is of very common occurrence elsewhere. In the Palikonda hill the rock is of a hornblendic variety, and of grey color.

A remarkably handsome variety of porphyritic hornblendic granite gneiss of rich green and pink colors occurs at the western base of the Nagari (Naggery) Nose mountain, and is exposed in several cuttings along the Madras railway (north-west line). Masses and boulders of this variety are to be seen included in large numbers in the basement conglomerate of the Upper Gondwána rocks in the Pyanur area south of the Nagari river.

The contrast between the rich dark-green hornblendic matrix and the large pink or salmon-colored crystals of orthoclase makes the rock a very handsome example of a typical porphyritic granite gneiss.

Quasi "brecciated" gneiss.

A by no means uncommon form of the granite gneiss is one in which the beds include masses of what appears to be an older gneiss, sometimes micaceous, sometimes hornblendic. The included masses present generally sub-angular forms, but others are well rounded, as if they had been boulders, and others again unquestionably angular, so that the mass looks sometimes conglomeratic, sometimes breccioid. In other places again, and often within the same beds and at no great distance, the inclusions have the appearance of having been altered by concretionary segregation. The included masses are mostly of finer grain and of more highly micaceous or hornblendic character than the surrounding masses. There can be little doubt that in some cases the included fragments are really remains of older rocks, and the whole rock a true breccia or conglomerate. In other cases, however, the inclusions are in all probability mere local aggregations of the prevalent or most striking mineral. An example of this latter kind is to be seen in the Chikeli Drug hill, a little to the south-east of Kaneambadi pass, nine miles south of Vellore. Good examples of this quasi-conglomeratic and brecciated structure may be seen to the west of the Nagari railway station, in the low hills close to the railway at Ranawaram near the Sholinghur station, and in the southern part of the district at and to the south of Chitpat (Chittapett), and at Erumbaucum, eight miles to the east-south-east of Arcot, and on the eastern side of the district at Gudinaucarur, six or eight miles east of Wandiwash.

Schistose band of Kailasagiri.

Of the more schistose bands of gneiss, the most noteworthy is the great micaceous band forming the Kailasagiri peak, six miles south-west-by-south of Vellore, which rises in a bold peak to an elevation of 2,677 feet above sea level. This gneiss is compact and massive in structure, and has been uptilted to a very high angle, the true dip of the beds varying from 80° to 85°. The strike of the beds corresponds with the direction of the highest part of the ridge and is north 5° east.

The very coarse garnetiferous micaceous gneiss of Chikeli Drug (already

[1] This place must not be confounded with the town and railway station of the same name on the northern boundary of Salem district.

referred to) extends northward into the Vellore hills, and forms a considerable part of the main ridge of the hill group.

Magnetite beds.

Beds of magnetic iron occur here and there in the south-west corner of the district, *e. g.*, to the south of Gudyátam (Goriattum), half a mile south of the great tank, and again two and a half miles west of Vellore railway station. These beds are small, but interesting, as there can be no doubt that they are representatives of some of the numerous beds occurring south of the Javádi hills in Salem district. Others of these richly ferruginous beds are in all probability represented by various quartzose gneiss beds, very strongly iron-stained, which occur in this quarter. The quartz of these beds is stained of purplish or reddish color, and frequently shows a brown ferruginous incrustation in the cavities between the laminæ, as also numerous little cavities in the lamination which appear once to have been filled by some mineral or other now wanting. These beds have a striking resemblance to the poorly ferruginous parts of many of the typical magnetic iron beds of the Salem region. Good examples of these iron-stained beds are to be seen in the Vellore hills and in the large detached hill three miles south of Vellore.

Quartzo-ferruginous beds.

Probable representatives of the magnetic iron beds are also the numerous quartzo-ferruginous beds noted by Mr. C. Æ. Oldham in the Arcot and Wandiwash taluqs. His notes unfortunately do not mention the form in which the iron occurs. The geographical situation points, however, strongly to these being continuations of the numerous magnetic iron beds occurring to the east and north of the Kabroyen mountains in South Arcot, beds which themselves are unquestionably north-easterly extensions of some of the great magnetite beds of Salem district. Associated with these quartzo-ferruginous beds in the south-eastern part of the district are also numerous beds of hornblendic ferruginous gneiss.

Hornblendic ferruginous beds.

These occur chiefly in the tract of country between Arcot and Wandiwash. To the eastward of this hornblendic band lies a broad zone of highly granitoid quartzo-felspathic gneiss which extends to the boundary of the Chingleput (Madras) district; the great Wandiwash hill belongs to this band.

In the more granitoid region north of the Pálár hornblendic forms are much less common than the quartzo-felspathic forms of gneiss.

Ferruginous beds were noted by Mr. C. Æ. Oldham, chiefly near the Poiney river, *e. g.*, north of Chellempollian; south-west of Bomupilli, eight or ten miles to the north-north-westward; and lastly, to the north of Maimandalum, on the western side of the Poiney river.

Talcose beds.

Talcose beds occur only in a few places. Three were noted by Mr. Oldham, all of small importance. They occur at Damavapak (Damarpauk), north of Arni, a little to the west of the road to Arcot, at a place on the left bank of the Poiney river, eight miles north-north-west of Ranipet cantonment, and lastly, a little to the south-east of Murtapilli and twenty miles north of the last named locality. An extremely quartzose band of gneiss is seen to the north-west of Sholinghur and north of Randareddi (Rundaddy).

In a district where so large an area is occupied by intensely granitoid gneiss, its characteristic features are of course to be seen to great advantage in many places, particularly along the two lines of railway diverging from Arconum junction. Especially characteristic are the hills of Maddur Drug and Trittan on the north-west line, and those of Sholinghur, Nelacontriapetta, and Gudyátam (Goriattum) on the south-west line; all of these show great bare masses of rock with tors, and here and there great precipitous cliffs.

Tors.

Of the tors the two most remarkable groups are both near Nagari; the one, between the railway and the foot of the Nagari mountain close to the northern end of the pass traversed by the old high road to Kadapa; the other, at Neddiem (Neddum) on the north bank of the Nagari river, four miles above the railway bridge. Both groups are of great size and height and form conspicuous objects from considerable distances.

A very common accessory mineral occurring in the granite gneiss is epidote, in its pale apple-green variety known as pistacite; it occurs scattered through the general mass of the rocks, or in minute veins, and very commonly as a thin coating to planes of jointing.

Rocks intruded into the Gneissic Series.

The crystalline rocks intruded into the gneissic series are referable to four groups—granite veins, felspathic porphyries, quartz veins, and trap dykes. Of the four groups, the last is by far the most important, and the first the least so, granite veins being very rare and of small size; the trap dykes, on the contrary, extremely numerous, and many of them of large size, and forming important features in the landscape in very many parts of the country.

Granite veins.

The granite veins seen in North Arcot are, with one exception, of quite small size, and all appear to consist of a binary rock, in which only quartz and felspar are recognizable. Some of them contain a few scattered crystals of epidote as an accessory mineral.

Numerous veins of very small size of dark salmon-red color, and highly felspathic in character, occur in the gneiss to the south of the railway station at Vellore, and a larger but still small vein of the same kind occurs at Vajur (Vanjoor), two miles south-west of the railway station.

The most important granitic protrusion noted is a vein occurring at Tarur (Turroor), eight miles east of the great Kaveripak (Covrepauk) tank, and about ten miles south-west of the Arkonum railway junction. It forms a bare and generally smooth ridge one and a quarter mile long, about 40 feet high at its summit. It is a binary quartzo-felspathic granite of coarse grain and full of minute cracks.

The very handsome green and pink syenitoid rock occurring at the western base of the Nagari mountain has been referred to before (p. 192) when treating of the gneissic rocks, but the rock is so extremely crystalline that it might easily be taken for a truly intrusive rock, and the more so as the position it occupies with reference to the surrounding unquestionably gneissic rocks is rather obscure.

The felspathic porphyries occurring in North Arcot district are very interesting,

Felspathic porphyries.

as being the only examples of this species of rock known in the south of the peninsula. Several very fine veins of this porphyry occur south of the Palikonda mountain (p. 192), and two of them may be traced for several miles in an east-to-west direction. In width they vary from 20 to 50 feet, and vary in color from smoky grey to pale drab, when freshly broken. Numerous prisms of flesh-colored or white felspar from ⅛th to ½ an inch long are included in the felspathic matrix. Small acicular crystals of dark green hornblende are less frequently included. The felspar crystals often stand out in great perfection on the weathered surfaces, and in some parts of the veins the included crystals form nearly half the mass. A little distance south of the western end of these two veins is a third in which the included small dark green acicular hornblende crystals are numerous, but the felspar crystals of rare occurrence in the greyish-white felspathic matrix. The felspar crystals are white and show very faintly.

On the east flank of the Palikondá mountain is a drab or pale buff-colored vein which appears to cross the mountain, for a precisely similar rock shows on the west flank. In this case the included crystals consist of felspar and quartz. Two other small veins of the same character appear on the west flank close to the north-west corner of the mountain, and a third of smoky grey color, with reddish felspar crystals, runs nearly east-to-west for two or three hundred yards parallel with the high road to Bangalore on the north side of the mountain.

Another small vein of the felspathic porphyry occurs in the centre of the valley west of Kailasagiri peak (south-south-west of Vellore); it is of the same character as those just described.

In point of age these porphyry veins seem to be newer than the trap dykes they cut in their course. Unfortunately this point could not be definitively settled owing to the presence of soil and debris at the points of intersection.

Quartz veins are not very common. A few were noted by Mr. Oldham in the

Quartz veins.

Wandiwash and Arcot taluqs; they are of good size (two to three miles in length), but offer no special features of interest; their course is either north-east-by-east to south-west-by-west, or north-west-by-north, south-east-by-south.

The trappean rocks seen in North Arcot district all occur in the shape of

Trap dykes.

dykes, often of great size and length, and forming important features in the landscape. They occur commonly in all parts of the district, and in the central part occur frequently in very large numbers.

The great majority of the dykes consist of coarse hornblendic trap, a form of greenstone, and there is in very many cases a direct proportion between the size of the dyke and the coarseness of the rock composing it. Many of the dykes are markedly porphyritic in structure, including numerous crystals of felspar in a hornblendic or hornblendo-felspathic matrix. If classified according to the directions of their courses, the dykes will be found referable to two great systems, of which the one runs north to south, roughly speaking, and the other east-by-north to west-by-south. In the former, the course is less constant, and varies by

5° or so east or west of north. A relatively small number of dykes does not come under either of these two systems, but they offer no special differences in mineral character, or otherwise to require any detailed notice. There is no marked difference between the trap rock forming the members of the two systems, and they appear to belong to the same geological age. Both agree in being older than the Kadapa system of rocks which they nowhere intrude into. The relations of the dykes at their crossings, are obscure in all cases in this district, but the intersections of other dykes of precisely similar rock and running in corresponding directions in more northerly parts of the gneiss area, *e.g.*, in Bellary district and the Raichur doab, appear to show that the filling up of both sets of fissures by the irruptive material was simultaneous, no difference or change of any kind being observable. Very large and important dykes, such as the great dyke at Sholinghur and some in the Maddur (Muddoor) and Trittani hills, rise to heights of several hundred feet above the surface, and form bold and striking ridges and crests.

Some of the dykes, such as the Sholinghur dyke and the Permalrajapet dyke, some eight miles to the east, are distinctly and strongly magnetic and affect the compass needle greatly. This phenomenon was also noticed in the dyke lying to the west-by-south of the village of Poiney, but not elsewhere.

Excepting a little pale iron pyrites (marcasite) no accessory minerals have been noticed in any of the dykes. The pyrites were seen in some of the dykes traversing the hill east of Vellore town.

Well characterized examples of porphyritic greenstones are to be seen to the south-east of Ranipet cantonment, and in the railway-cutting south of Pudi station on the north-west line of the Madras railway. As a rule, with few or no exceptions, the greenstone weathers more slowly than the surrounding gneissic rock, and consequently the dykes form ridges running over hill and dale, and from their dark color contrasting strongly against the gneiss.

The courses of many of the dykes may be followed for twenty or thirty miles or even more, and the larger ones have a width of from 50 to 100 paces. The network formed by these multitudinous dykes is one of the most remarkable displays of trappean injection known in any country.

THE KADAPA SERIES.

The representatives of the Kadapa series are confined to the north-eastern corner of the district, where they form, as already pointed out, the main mass of the Nagari group of mountains, the Tripatti hills, and the extreme south end of the Vellakonda range. The remarkable and highly picturesque scenery of this region is due to the great mural scarps into which the massive quartzite beds have been worn.

Chief outliers.

The Nagari mountains form several outliers detached from the main area of the Kadapa rocks, of which the Tripatti hills and the end of the Vellakondas form the southernmost extremities. The principal outliers are four in number, the Nagari Nose mountain forming the most southernly of the number. North of this is the Narnavaram ridge, a long narrow ridge lying north-east of the village of Narnavaram, and not to be confounded with the Narnavaram peak, which forms the southern end of a large outlier which includes the Saddashemallai or Sathuskonda, the highest member of the Nagari group, and the mountains south of Kálabástri (Calaetsy). The fourth large outlier includes the Ránsagiri and the Kambákam (Cumbaucum) Drug mountains.

Petrological characters.

Many of the quartzite beds which rest on the gneiss in marked unconformity are coarsely conglomeratic, including pebbles of gneiss, quartz, and occasionally of ribbon jasper. The quartzites are generally very massive, and semi-vitreous in texture, and occur in thick beds which often show but little lamination. The surface of some of the beds is often covered thickly with small annular markings, as if they had been stamped all over with an ordinary wad-cutter. No satisfactory explanation of the cause of these markings had yet been offered. In some beds the rippling caused by current action has been beautifully preserved.

The prevalent colors of the quartzites are pale greys and drabs, all weathering to shades of buff or pale orange. The principal lines of scarp face the south, *e. g.*, those of the Nagari Nose, the Narnavaram peak, the Saddashemallai, and the Tripatti mountains, but very fine east and west scarps are seen on the Ránsagiri. The three scarps first mentioned are in many parts quite vertical, and form perfectly bare walls of rock from a few hundred to over a thousand feet in height. The smaller outliers show some of the lowest beds, but are of no special interest.

The whole of the beds exposed in the North Arcot district belong to the second lowest of the divisions recognized in the Kadapa series by Mr. King[1] and called by him the Nagari series, a yet lower series underlying the Nagari beds having been recognized by him further north near the Papagni river in Kadapa district.

The most southerly recognized outcrop of the Kadapa beds is the Nagari Nose mountain, but it is not improbable that some large detached masses of quartzite occurring at the base of the Gondwána rocks at Naikenpalem, eight miles further south-east, ought to be regarded as relics of the basement bed of the Nagari group. These masses of quartzite will be referred to again further on.

THE UPPER GONDWÁNA SERIES, RAJMAHAL GROUP.

The great series of rocks known under the name of the Upper Gondwána, which occupy a very important position in the northern half of the peninsular area, are represented in the Madras region by considerable formations of great interest, because they contain fossil plants, some of which are identical with those occurring in the Upper Gondwána formations of the Rajmahal hills in Bengal.

Their representatives in North Arcot occur in two positions, one north, the other south of the Pálár. In the first we may conveniently distinguish three localities, the Sattavedu, the Alikur (Alcoor), and the Pyanur areas; in the second there are some twenty-five small patches scattered widely over the surface of the gneissic area in the Arcot taluq, a few miles south-west of Con-

[1] See Memoirs Geological Survey of India, Vol. VIII.

jeveram. The most important and the greater number of these patches lie around the great Mámdur (Maumdoor) irrigation tank, and hence the group may be conveniently called the Mámdur group. Three small outlying patches occur twenty miles further to the south-west in the Arni zemindari. This group of small patches are evidently the remnants of a once extensive spread of the Upper Gondwána rocks, which, in all probability, was continuous with the beds of the same age to the north and north-east, and very likely also extended far enough southward to join the Utatur (Ootatoor) "plant beds" in Trichinópoly district.

Great denudation, especially in the area south of the Pálár, beginning probably in precretaceous times, separated the Gondwána rocks into the many detached outliers now enumerated, while their surface is largely obscured by the overlying younger lateritic and alluvial formations.

Division into two groups.

As before mentioned, the Upper Gondwána beds of the Madras region have been divided into two groups, called after the localities in which best developed, the *Sattavedu* and *Sripermatur* groups; the division is chiefly based on petrological differences, the actual stratigraphical relations being very obscure and somewhat doubtful owing to the insufficiency of existing sections.

The Sattavedu group.

The Sattavedu group, which consists mainly of coarse, well consolidated conglomerates and sandstones of great thickness, forms the mass of the Sattavedu and the northern and eastern parts of the Alikur hills, while beds of uncompacted conglomerate with intercalated clays and shales appear to underlie the hard Sattavedu beds in the western and southern parts of the Alikur hills. Unfortunately no section exists (or existed) showing the two sets of beds in actual contact, hence their stratigraphical relations are still doubtful.

The Sripermatur group.

The soft beds have been referred provisionally to the Sripermatur group on petrological grounds, the resemblance of the softer rocks being much stronger to the rocks found in the Sripermatur outcrop in Chingleput district, than to the coarse and compact conglomerates and sandstones of the Sattavedu and eastern Alikur hills.

The Sattavedu area.

The whole of this outcrop is made up of alternate bands of hard conglomerates and sandstones, many hundred feet in aggregate thickness, and of more or less red color. The conglomerates are made up of large well rounded smooth quartzite pebbles, with a small number of similar pebbles of granite gneiss, the whole strongly cemented by a matrix of variable character, sometimes argillo-ferruginous, ferrugino-arenaceous, or more rarely siliceo-calcareous. The sandstones are mostly rather gritty in texture, and contain here and there a few plant remains, among which Mr. King found a frond of *Dictyozamites indicus*, one of the most characteristic Rajmahal plants. The beds have a generally eastward dip at moderate angles. The area of the outcrop is nearly co-extensive with that of the hill group, and measures about sixteen miles.

The Alikur area.

The Alikur area is separated from the foregoing only by the narrow alluvial valley of the Narnavaram river, under which the beds are doubtless continuous. The eastern half of the Alikur hill group consists of hard conglomerates and sandstones, apparently continuations of the beds forming the south-western part of the Sattavedu hills. Like these they have a more or less easterly dip, and disappear under the lateritic beds, which lap round the eastern foot of the hills, and which, together with the great talus which has accumulated on the base of the slopes, completely obscure all the relations between the lower and upper rocks. No fossils were found in the Alikur hills. The hard beds occupy only about a third of the area of the Alikur outcrop, the remainder being formed of the soft beds assumed to belong to the Sripermatur group, and which, as already mentioned, appear to underlie the hard beds conformably. No section was found showing these two dissimilar series in contact where they approach each other in the centre of the Alikur hill group, but as far as the rounded outlines of the hills at that point serve to guide the eye, there is an undoubted dip of the softer beds under the hard conglomerate. No sign of any fault could be traced, but from the peculiar nature of the case, a fault of great importance might well exist, and yet be completely hidden by the vast quantity of debris and talus which everywhere almost cumber the surface even of steep slopes. The nearest visible approach of the two series is a short narrow east and west ridge abutting at right angles against the hard basement conglomerate of the Sattavedu series, which here forms a conspicuous north and south ridge parallel with several of similar character further east, each representing a great conglomerate bed. The valleys running down north and south from the cross ridge are the two principal ones in the central mass of the hills, and their depth, which is considerable, is due to the greater softness of the underlying beds as compared with the overlying set.

The soft beds so frequently named consist of conglomerates, gritty clays, and shales of white or grey colors. Even the coarsest conglomerates at the very base of the series are uncompacted and soft, the enclosed pebbles and boulders of gneiss and quartzite merely lying embedded in very friable more or less clayey grit consisting of quartzose debris of gneissic origin. The slopes of the hills composed of such soft beds are deeply covered by debris, while but few of the rain gullies descending from higher slopes penetrate sufficiently to expose the rocks *in situ*. The Naikenpalem hills, which occupy the southern part of the Alikur area, consist, as far as seen, entirely of the soft beds which have trended round from a north and south strike in the Alikur hills to one running west-north-west to east-south-east.

Numerous plant remains were obtained from a clay bed exposed in one of the principal rain gully sections east of Naikenpalem village. Amongst the remains were parts of *Tæniopteris*, *Dictyozamites*, *Ptilophyllum*, &c., all characteristic Rajmahal plants. Unfortunately the specimens, which are beautifully distinct when freshly extracted, are utterly ruined by the shrinkage of the wet clay as it dries.

Included masses of quartzite.

Near the village of Naikenpalem the basement bed includes enormous masses of conglomeratic quartzite, some of them from 800 to 1,000 cubic feet in bulk; these are very probably relics of the basement bed of the Kadapa series, which is so generally represented a few miles to the north-west and north in the great scarps of the Nagari mountain and the Ramagiri. These great quartzite masses are not seen resting actually on the gneiss surface, but it can only be a few feet below the local surface of the slope; it is only reasonable, therefore, to look upon them as ruins of the once existing conglomerate bed forming locally the base of the Kadapa rocks, which was nearly all removed by denudation. In view of the enormous amount of denudation the shapes of the Nagari mountains show them to have undergone, there can be no difficulty in accepting this solution of the problem. If the blocks be not, however, really *in situ*, their existence in their present position is even more remarkable, as no known agency, but that of floating ice, can explain their presence. The appeal to glacial agency in such a southerly latitude would not be justified except on the very strongest evidence.

The Pyanur area.

The character of the rocks in the Pyanur area changes slightly, the included boulders and pebbles in the conglomerates are more frequently of gneissic origin and less exclusively of quartzite. They are embedded in equally soft and uncompacted beds. Fossils are very rare; none were found except in a friable sandstone exposed in the left bank of the Nagari river opposite Chittapuram, a little below the junction of the Trittani river. Fragments of *Tæniopteris* and *Dictyozamites* were here obtained.

The basement conglomerate in many parts of the Pyanur area was deposited around and includes large water-worn masses of gneiss forming boulder beds similar to those occurring in the base of the plant beds at Utatur and elsewhere in Trichinopoly district, and similarly at various places in the Ongole group of outcrops in Nellore district.

The hard white and mottled shales so typical of the Sripermatur group in its proper basin do not occur in any of the outcrops in the Arcot district, but some of the clays exposed in the south-eastern corner of the Alikur area show signs of passing into a shaly condition, and appear to do so further to the north-east in the valley of the Alikur nullah.

Mámdur patches.

Outcrops south of the Pálár.—The petrological features of the southern or Mámdur group of outcrops, as well as their geographical proximity, justify their being assigned to the Sripermatur division of the Rajmahal beds. As they were visited only by the late Mr. C. Æ. Oldham, it will be better to quote the description, as far as possible, in his own words as given in his notes.

Thechur outlier.

The three most westerly outcrops, which have already been mentioned as lying about twenty miles south-west from the Mámdur group, are situated close to the village of Thechur, seven miles south of Arni. Here to the south-west of the village occurs a "greenish-yellow shaly sandstone," which "is also dug out from wells in the village." "East of the village I noticed another minute patch."

Conteantandalam.

Of the patches forming the Mámdur group, Mr. Oldham remarks in his notes: "At Conteantandalam, the most easterly of these localities, several wells and bowries, in and near the village, expose about 12 feet of these beds," which are chiefly a soft yellow sandstone thick-bedded, but in the lower portion some harder compact beds occur; and a coarse conglomerate containing numerous pieces and pebbles of quartz and gneiss in a hard silicious matrix has been quarried to some extent from under the soft beds.

Doshi outcrop.

After mentioning a narrow and thin slip of hard ferruginous sandstone close to the ford by which the Conjeveram-Wandiwash road crosses the Pálár, Mr. Oldham describes the interesting outcrop at Doshi (a mile and a half to the south) thus:—"This locality and its immediate neighbourhood, though not affording even a single tolerable section, yielded to me the great majority of the fossil specimens, all plants, which I succeeded in procuring from this series of beds." "In a small tank west of the village I noticed a little yellow sandstone in flat beds just appearing above the surface of the water when low, and from the bund of this tank, which is largely composed of the pieces of this and other beds thrown up when it was dug, I succeeded in obtaining numerous plant remains." "I could not discover a trace of mollusca or other animal remains, but in some of the beds of sandstone the plant remains are very abundant."

Plants found.

"Until they have been more carefully examined and compared, I cannot attempt to do more than indicate their general character, which is very similar to that of the Rajmahal flora, presenting *Palæozamia (Ptilophyllum)*, *Tæniopteris? Stangerites (Angiopteridium)*, *Pecopteris*, and *Sphenopteris*." "I obtained also specimens of circinnate vernation of ferns. These remains occur in great abundance, principally in thin-bedded yellow sandstones, but some of them also in a coarser thick-bedded sandstone." "This strip of sandstone has its limits narrowly defined by the appearance of gneiss *in situ* closely on the east, north, and south, and at no great distance on the west also."

Mámdur section.

"About four miles west of Doshi is the best section seen of these beds. This is exposed in the old supply channel which runs from the river Pálár near Umiaveram to the large Mámdur tank, in the banks of which and the small watercourse adjoining a fair section is exhibited, showing a greater thickness of beds than I was able to discover in any other locality." "Proceeding southward along the channel we get the following section. The first (lowest?) bed seen is a coarse white felspathic sandstone with small pebbles of quartz, from 3 to 4 feet in thickness, rather soft and scarcely consolidated, at least superficially. I could here detect no organic remains whatever. Over these lie about 3 feet of a finer yellowish sandstone with minute shaly partings of a greyish-white color." Above this are 5 feet of a hard ferruginous sandstone, the uppermost bed of which has a curiously tesselated appearance due to concretionary structure, assuming generally a pentagonal arrangement. All these beds have a low dip of 2° or 3° to the south and south-south-west. "Passing onward the section in the channel is broken and obscured by soil, &c., but the missing portion seems to be, at least in part, supplied by the smaller gullies, watercourses, &c., on either side, which show a few feet in thickness of yellow and white sandstone apparently overlying the ferruginous bands and dipping south-by-west at an increasing angle. Proceeding still southward along the channel, we come upon a hard brown ferruginous sandstone dipping south-south-west at 32°. Of this only 2 feet appear, and over this from 20 to 25 feet of a soft rather coarse yellow sandstone with a few harder ferruginous partings, all dipping south-south-west at from 30° to 35°. Over this with a dip in the same direction, but at gradually decreasing angles, are rather coarse clunchy yellow sands, thick-bedded and only moderately consolidated. Of these about 25 feet appear overlaid by about 10 of thinner-bedded yellow sandstones of much finer grain with thin greyish shaly partings. These are apparently the highest beds[1], shown in this section, as on proceeding along the channel we find them turning up with a considerable dip of 25° to 30° to north and north-by-west." From under these again appears the coarser thick-bedded yellow sandstone which continues to show along the channel for a distance of about 200 yards, with here and there some of the thinner beds appearing in the banks above. Still following the channel, as it turns south-east and east-south-eastwards, these coarser beds continue to appear, having a rolling dip to the north-north-west." From under these rises with westerly dip a strong brown ferruginous sandstone which only shows for a short distance, and is the last and lowest bed seen in this direction, disappearing at a point due north of Namdi (Naumdee), a quartzo-hornblendic gneiss appearing a very short distance to the east. A yellow sandstone very similar to the upper beds of the section just given appears in bowries and in a little watercourse north-west of Namdi.

The small outcrop west of Tallicalli and north of the channel section just described shows coarse pebbly ferruginous sandstone. The outlier west-by-north of Tripnagad and that south of Umiaveram show coarse, white felspathic sandstone, associated, in the latter case, with a little thin-bedded ferruginous sandstone of brown color. At Cutanur, two miles to the west of the last-named outlier, a greenish-yellow somewhat shaly sandstone underlaid by a coarser yellow felspathic sandstone is exposed in well and tank sections. A coarse ferruginous sandstone forming a small patch at the north end of the Manapakam tank, four miles south-west of Cutanur, is the most westerly extension of the Gondwána rocks in this quarter.

Three miles further south-east and east of the village of Asuapetta, and again a mile to the south of the village, "we find patches of hard conglomeratic sandstone containing large pebbles of quartz. This is superficially ferruginous and of a reddish-brown color, but when freshly broken of a dull grey. It lies in thin beds on the surface of the gneiss."

Jaderi section.

Proceeding south "along the road between Asuapetta and Trivatur, we cross four distinct patches of sandstone, in the most northerly of which a tolerably good section is exposed in a supply channel running in to the tank at Jaderi (Bathary"). Here resting on the surface of the gneiss is a hard very silicious close-grained sandstone, but frequently containing large pebbles of quartz. Of this there is a thickness of several feet, showing only at intervals and not well seen. Above this, passing east along the channel, we find a coarse felspathic sandstone of no great thickness (2 to 3 feet),

[1] "From these highest beds I procured the only specimens of organic remains that I was able to secure from this locality. Owing to the soft, crumbling nature of the rock, much increased by heavy rains which had fallen recently, it was almost impossible to obtain specimens that would bear carriage. Several which I extracted came to pieces in my hands. Those which I succeeded in carrying away were *Palæozamia ? (Ptilophyllum)* and *Pterophyllum ?* I noted also *Tæniopteris* and *Pecopteris*."

with locally a fine grey shale, in which some fragmentary stem markings were noticed. All these have a low dip of 2° to 3° east." Above all is a ferruginous sandstone, 1 to 1½ feet thick and of rather coarse texture.

Small outcrops north of Trivatur.

The other three patches which are seen crossing the road consist of a hard superficially generally ferruginous sandstone, similar in character to the lowest bed of the above section. A patch of similar beds covered by a little yellow sandstone occurs east of the road about two and half miles north of Trivatur. Between three and four miles north-east of Trivatur and east of Perintur occurs a little hard grey sandstone, about 10 feet thick and weathering of a reddish-brown.

Three miles to the north close to Marianur, a large amount of debris of a reddish ferruginous sandstone covers the ground, and close to the village on the south this is seen *in situ* overlying a coarse brown felspathic sandstone, of which but little is seen, though it has been thrown up in considerable quantity from well and tank sections. In the village a tolerably hard yellowish-brown sandstone is dug out of bowries (large square wells) and has been used to a small extent for building. A similar brownish-yellow sandstone is also dug out at Shamanguri, two and half miles to the north-west.

A few more small patches might be referred to, but they offer no special characters of interest.

The numerous patches just referred to are, without exception, of small size, the largest not being more than two miles long by one in width at its widest part, and the great majority greatly less in dimensions.

THE LATERITIC FORMATIONS.

Of the numerous spreads of the lateritic rocks which fringe the eastern coast of the peninsula between Latitude 13° 50′ and 11° 20′ north, only a few extend inland sufficiently far westward to come within the limits of the North Arcot district. There is, however, abundant evidence that these rocks had formerly a much wider westerly extension, and that their present western limits are boundaries of denudation and not of deposition. The chief outcrops of them occur along or close to the eastern boundary of the district, and are in most cases seen to rest upon the Upper Gondwána beds, to which, however, they are markedly unconformable, and in many cases they overlap on to the gneiss. All the outcrops of importance lie to the north of the Pálár.

The most southerly patch of lateritic beds requiring notice lies between the north bank of the Pálár and the alluvium of the Kortelliar, about twelve miles east of Arcot town. It is in reality only the extreme western end of a very large lateritic area which occupies further eastward nearly the whole of the Conjeveram taluq. The prevalent rock here seen is of a red sandy variety with scattered patches of ferruginous gravel.

Shingle conglomerate.

To the north of the Kortelliar the laterite occurs in the form of an enormously coarse shingle or generally uncompacted conglomerate, such as may be seen at and to the south of the Chinnamapett railway station. Further north the surface of the Pyanur area of Rajmahal beds is widely covered with an equally coarse shingle associated with large quantities of ferruginous gravel and clay binding the whole into a semi-compact conglomerate, which is the general character of the lateritic beds further north round the base of the Naikenpalem, Alikur, and Sattavedu hills, the coarseness of the included shingle and the amount of ferruginous cement associated with it being locally of variable quantities. Where the shingle, which consists almost entirely of quartzite, attains a great degree of coarseness the ferruginous matrix is often masked to a very great extent, the peculiar vermicular cavities so characteristic of non-conglomeratic laterite are never seen, and the correlation of the two varieties as members of one and the same geological formation is made entirely upon stratigraphical grounds.

The principal lateritic areas lying westward of the eastern boundary of the district are those along the western base of the Ramagiri and the eastern base of the Nagari mountains, and some spreads in the valley of the Swarnamukhi river near the Madras railway at Karkambadi. In the two first of these areas the rock is much less coarsely conglomeratic than around the Alikur and Sattavedu hills and over the Pyanur area.

The surface of the Pyanur laterite patch is very thickly strewn with the extremely coarse quartzite shingle weathered out of the underlying conglomerate, and in many places progress even on foot is by no means easy across the great smooth and highly slippery stones. The surface is so extremely stony that great tracts remain waste. That a very flat country should be so inaccessible owing to the thickly strown products of partial weathering of the rocks forming the surface is a very singular phenomenon.

Debris of lateritic beds.

Remains of lateritic beds are very numerous to the westward of the present westerly boundaries of the formation. Many such remains were noted as much as six or eight miles away from the nearest of the undisturbed beds, and a closer search of the country would probably show such ruins even far further in that direction. The greater westward extension of the lateritic rocks, before adverted to, is thus abundantly proved.

Occurrence of stone implements.

Proofs that the lateritic formations were, in part at least, formed since man's advent on earth are numerously met with in the North Arcot laterite patches in the form of well-shaped chipped implements of palæolithic types made of quartzite. Many of these were discovered by the geological surveyors in nearly all the lateritic patches, and in many cases also among the debris marking the sites of the now denuded parts of the old extensions., *e. g.*, among the gravelly ferruginous debris lying in the surface of the gneiss at and around the Arkonam railway junction at an elevation of more than 300 feet above sea level.

Elevation of lateritic beds.

The highest elevations to which the implement-bearing lateritic rocks have been traced in this region are the neighbourhood of the Madras railway at Karkambadi, in the Swarnamukhi valley, and the westernmost slopes of the Naikenpalem hills; in the former case, the implements occur at an elevation of 370 feet above sea level, in the latter, at a probable elevation of between 500 and 600 feet. The Karkambadi beds yielded a great number of fine implements to the search of Mr. W. R. Robinson, C. E., Chief Engineer of the Madras Railway, when Resident Engineer at that place.

Age of certain shingle beds.

There can be little doubt that the great accumulations of well rolled quartzite shingle which rest on the southern bank of the Nagari Nose mountain and on the flanks of some of the mountains further north must, in part at least, be reckoned as of the age of the lateritic period, as they correspond closely in position and mineral character with the higher-lying lateritic beds just mentioned. The Nagari Nose shingle bed is deeply stained with iron from the ferruginous matrix which must have once surrounded the perfectly non-ferruginous quartzite shingle, for that is the only way of accounting for the deep and indelible purple-red color borne by the natural pale-colored quartzite. As now seen, the shingle suggests instantly the idea of its being an old raised beach.

The origin of the lateritic formations, owing to the total absence of all organic remains (the chipped implements being only indirectly of organic origin), is wrapped in obscurity and doubt. Three theories have been propounded to explain the existence of these formations which fringe the western and eastern sides of the peninsula from a little south of Bombay right round to Cuttack and still further north. The three theories have been discussed at some length, each having something in its favor, but they are still *sub judice*, and this is not the place for continuing the discussion.[1]

They may be briefly designated as the marine, the fluviatile, and the subaerial. As at present seen, none is altogether sufficient to explain the various difficulties, and it is very possible that all three must be enlisted before more light can be thrown on the subject.

THE ALLUVIAL FORMATIONS.

The alluvia occurring within the North Arcot district are all of fluviatile origin, and occupy the valleys of the principal rivers, but are developed only to a very moderate extent, and would offer no points of special interest were it not that in two cases there is evidence of the rivers having changed their courses widely and formed a second series of deposits in other valleys.

Change of course of the Pálár.

The first of these cases is that of the Pálár, the principal river of the district, which now flows into the sea forty-two miles south of Madras, but which formerly flowed down what is now reckoned the alluvial valley of the Kortelliar river and entered the sea somewhere to the north of Madras, probably between Gunore and Pulicat. A glance at the geological map will show that the present valley of the Pálár is very disproportionate in size to the river, and equally that the alluvium of the Kortelliar is greatly disproportionate to its river, which now flows in a deep channel.

[1] For the discussion of these theories, the reader is referred to Mr. Foote's papers on the subject of stone implements in Southern India in the Madras Literary Journal for October 1866, the Quarterly Journal Geological Society of 1868, p. 484, and the Memoirs Geological Survey of India, Vol. X, pp. 54, &c. Also stone implements of Great Britain by John Evans, D.C.L., F.R.S., and lastly, to the *résumé* by Mr. W. T. Blanford, in the Manual of the Geology of India (Vol. I, pp. 368-370), of the facts known about the low-level laterite.

The two valleys diverge at a place about ten miles east of the town of Arcot, and a small stream (or irrigation channel) still branches from the Pálár here and flows down the Kortelliar valley for many miles and eventually joins the latter river. To this stream the natives have given the Sanscrit name of Vridacharanadi or "old milk river," the Tamil name of the main river "Pálár," also signifying "milk river." The alluvium occupying this valley consists of coarse gritty loose silicious sand of gneissic origin.

Change of course of the Nagari river.

The second case is that of the Nagari (Naggery) river, which in former times appears to have fallen into the Narnavaram river, just south of the Ramagiri, and close to the village of Nagloperam. The present course of the river lies down the old alluvial valley for a little more than three miles east from the railway bridge. It then turns sharply south-east, leaves the alluvium, and flows through a cutting in the gneiss about a mile and a half long and falls into the Trittani river, which joins the Kortelliar a few miles further east. In consequence of this the broad alluvial valley which runs between the Nagari mountain and the Alikur hills is now drained only by small streams and artificial channels. The alluvia deposited by the Nagari river both in its old and new valleys consist almost entirely of coarse gritty sand like that of the Pálár. No alluvium appears to be deposited at present, but the streams seem to be cutting their beds deeper and deeper every season.

No information was procurable from the natives as to the time when these changes took place, but the probability is that, geologically speaking, they are of very recent date, as may be inferred in the case of the Pálár from the name given to the channel which still falls into the Kortelliar; and in the case of the Nagari river, from the fact that the cutting through the gneiss by which the river escapes from its old alluvial valley presents every appearance of being of artificial origin, and must in that case have been the work of a people boasting some considerable civilization.

THE SOILS AND SUB-AERIAL FORMATIONS.

Of the soils in North Arcot little need be said; they appear, as a rule, to be the product of the weathering of the local rocks, or to have been brought from but trifling distances by pluvial action. The prevalent soils are red, and of these the sandy form is the most common.

Of the sub-aerial formations the only really interesting and important ones are the taluses around the quartzite-capped mountains in the north-eastern corner of the district. As already pointed out, the talus accumulations are two-fold, and consist partly of great collections of well rounded shingle referable to the lateritic period, and above them of the angular unrolled debris detached from the great scarps by atmospheric agencies, which debris here now shows the deep ferruginous stain characteristic of the lateritic shingle beds. On a greatly smaller scale, but still of considerable importance, are the talus accumulations on and around the newer Rajmahal and lateritic formations in the Sattavedu, Alikur, and Pyanur areas. These consist in both cases almost entirely of well rolled quartzite shingle weathered out from the many important conglomerated beds occurring in both series.

ECONOMIC GEOLOGY.

The information on this branch is not so complete as might be wished, owing to the non-completion of the survey of the district. The granitoid gneiss occupying the greater part of the gneissic area offers nothing but building stone; but of this much is of great beauty and value, and has been very largely used for many large native buildings, as the forts at Vellore and elsewhere, and among European buildings, particularly in the construction of many railway stations, bridges, and culverts.

Kaolin.

The highly felspathic varieties of the granite gneiss are occasionally so greatly decomposed as to appear to offer sources for the collection of kaolin or China clay. When carrying on the survey of the Vellore and Eudialtham taluqs, I noticed various spots which appeared to me to be deserving of attention with this object till I had seen some of the great China clay works in Cornwall, which I visited specially for the purpose of study when at home in 1868.

The conclusion I then came to was, that none of the North Arcot localities showed rocks sufficiently rich in decomposed felspar to be of much importance. The extent to which the Indian rocks have been penetrated by decomposition is greatly less than the Cornish rocks, and the quantity of clay which would therefore be procurable in India would, area for area, be greatly smaller than in Cornwall. Added to this very serious disadvantage is the difficulty of a suitable water-supply. To insure the preparation of kaolin of good color, which alone commands a high price, a very large supply of perfectly limpid water is a *sine-qua-non.* This is not always easy to obtain even in a rainy climate like that of the south-west of England, where running streams are of frequent occurrence, and in a dry climate like that of the Carnatic, this want could only be met by the construction of special reservoirs of large size, in which the water could be allowed to stand for many months after the rainy season, till all the suspended particles of ferruginous clay had settled, and the water itself has become perfectly limpid. If the great cost of providing such supplies of limpid water free from saline matter in an eminently dry country be taken into consideration, together with the fact that the kaoliniferous decomposed rock occurs in greatly smaller quantity, and is generally much less free from ferruginous staining due to the filtration through the almost universally overlying red soil, the conclusion seems inevitable that the prospects of establishing profitable China clay works in North Arcot are not very promising.

Building stones.

To return to the subject of building stones: the rocks of the gneissic series alone offer an inexhaustible supply, and localities which would yield first rate material in any quantity might be enumerated by the score, if needful. The mention of only a few must, however, suffice; these are Palikonda hill, Vellore, Wandiwash, and Chitpat, south of the Pálár, and Ranipet, Sholinghur, and Trittani, north of that river.

The quartzites of the Kadapa series are too hard and expensive in working to be used except as rough building stones; and the sandstones of the Rajmahal beds are not hard enough, except in a very few cases, to be of much value. Neither Mr. Oldham, Mr. King, nor myself came across any that were fit for first class purposes, such as millstones or grindstones. Nor were any of the clay beds noted in the Alikur and Pyanur areas of sufficiently good color to be of much value. The pottery clays used by the people are taken from the younger lateritic or alluvial deposits, and are, as a rule, of very inferior quality.

ON THE CONTINUATION OF THE ROAD SECTION FROM MURREE TO ABBOTTABAD, *by* A. B. WYNNE, F.G.S., *Geological Survey of India.*

In a former paper (Vol VII, p 64), I described the section from Murree to Kalabagh Post, along the upper or military road through the *galis* ("gullies"), as it is usually called.

At Kalabagh, the summit level of this road (about 8,000 feet by aneroid), the nummulitic limestone and shales of the hills are in junction with the azoic Attock slates of the Mian-jani-ka Chowki range, this junction being apparently effected by means of a fault concealing all of the intervening rocks that may be present. The slates are much folded and, about half way between Kalabagh and Baragali, include a band of the usual frilled, dolomitized, seemingly slightly altered and entirely unfossiliferous limestone found elsewhere in these slates. It extends in the strike across the ridge supporting the road, and similar bands may be seen projecting at the surface of a spur from Mianjani mountain, and forming the crest of another ridge running out westward from Baragali, in both cases with a northerly dip Near the last-named place the slates contain bands of hard dark grey or bluish silicious sandstones, and further on down the steep incline to the northwards at Bantangi purplish-red slab-slates occur near the junction with the limestones of the northern side of the great Mianjani slate tract.

The junction here differs from that at Kalabagh, but has scarcely less the appearance of a faulted or dislocated contact, the plane of which is partly vertical and partly sloping to the north, for on the western side of the Batungi Kad, the limestone, almost entirely concealed by dense forest, slopes upward and backward to the south, while the whole hill face on the opposite side of the Kad is of slate, as usual crushed, contorted, and folded.

Just at the contact, where a purplish color pervades the slates in some places, the next adjacent rocks are vertical light-colored quartzites, of small thickness, succeeded by compact and sandy limestones containing many impressions and sections of brachiopods, mostly of small size, many of them resembling casts of *Terebratula;* some obscure spiral gastropods, and some layers crowded with the curved fragments of small bivalves also occur. These hard limestones have nothing beyond the most general similarity to the hill nummulitic limestone beds; they are often dark or nearly black, and some of the bluer layers present a curious but characteristic yellow-mottled appearance frequently observed in the limestones of the Dungagali and Changlagali road, where these have been supposed of triassic age, for which, however, there seems little more than a conjecture on the part of Dr. Waagen, as the fossils, when the beds contain any, are mostly very obscure. Other beds show a tangled mass of fucoids on the surfaces. These limestones are largely distorted, forming at first a complex synclinal curve crossed by the throat of the Batungi gorge. Before leaving this narrow part of the gorge and turning eastwards towards Bagnotur, the road crosses a small hollow in the limestone hills north of the synclinal arrangement of the beds. In the hollow and on the slopes on the opposite side of the Kad some small *dogas* or field terraces show the waste of dark shaly rocks, so that possibly some fragment of Spiti shales may here occur, to mark a boundary. Beyond this hollow and until the road has curved eastward, the dark limestones become more like the lowest of the nummulitic ones; they contain disseminated and nodular pyrites and a thin band or bands of very dark coloured ferruginous clay with rounded quartz grains and spangles of mica, but no fossils could be detected. Just at the turn some broken and detached portions of what may once have been a more continuous layer of dark ferruginous oolitic hematite clay is enclosed among the limestone beds. It has slight resemblances to the golden oolite of the Salt-range and Kach, but is not identical with that rock. A little way beyond it the limestone, if it has any general dip, slopes southerly, and the first distinct traces of nummulitic fossils appear in foraminiferous forms distinguishable with a good lens, amongst them the little organisms referred to in a former paper (Vol. X, p. 114), and tiny *Rotalina*-like forms, as well as little nummulites, most of which might escape observation with unassisted eyes.

At Bagnotur one has descended some 3,230 feet (aneroid) from Kalabagh, within a distance of five miles by the road (much less in a straight line), and just before reaching the bungalow or rest-house, the Attock slates again appear, occupying, beneath enormous masses of debris, the lower part of this valley and that of the river Dore coming from the eastward, which here unite. The slates continue in this position, chiefly on the south side of the Dore valley, uniting eastward with the main mass of the Mianjani exposure, so that the limestones just now mentioned form a tongue stretching in the direction stated from those occupying much of the northerly parts of the lower Hazara hills. As it is the nummulitic part of these limestones which occurs in junction with the slates and not one of the older groups, it may be presumed the contact here again is effected by a fault.

Following the Abbottabad road from Bagnotur downwards to the bridge over the Dore, 670 feet below the bungalow, another apparently faulted junction with the limestones is crossed before reaching the lowest point. These limestones dip north-westward, are strong-bedded, compact, and of dark-grey colour, containing small fragmentary fossils, amongst which I observed the basal portion of a shark-like fish tooth. They are sometimes semi-oolitic, and sometimes contain knots or blebs of carbonate of lime, the whole assemblage having the aspect of the supposed triassic limestone of these hills.

Where the Dore bridge spans the chasm below this point, similar limestones dip at high angles to the eastward, and rising from the bridge high over the northerly channel of the stream, they are seen to include a 10-foot band of purple and light-coloured ferruginous shale lying between dolomitic and dark lumpy bands. Further on dirty brown limestone is full of shell fragments, and again solid limestone alternates with shaly bands.

This gorge is the most profound traversed by the road; on one of the mountains close to the westward, overlooking it, a height is marked of 6,645 feet; and supposing the stream to be 4,200 feet, the section exposed in the steep mountain side may be nearly 2,000 feet in height. The rocks for about a mile in the narrow part of this gorge are all of the triassic aspect just now described, and they are seen to be contorted in the wildest fashion, a group of hard beds showing their edges vertically for some hundreds of feet, and standing as it were upon a strong horizontal outcrop below, as well as presenting in other places a variety of compressed curves. Leaving the narrow part of the gorge and descending into the valley of a small tributary from the east, the Attock slates are again exposed, forming a small denuded inlier, beyond which northwards crags of the disturbed triassic-looking limestone reappear. Just beyond this, the Doro river bends to the west, and in its further bank (the left), there is an exposure of black Spiti shale with fragmentary Ammonites and many Belemnites as usual. From this onwards, the road rises high above the right bank of the river, and passes along cuttings in much contorted nummulitic limestone, with two or three exposures of black coaly or carbonaceous shale, associated with ferruginous and quartzite sandstone. Black shales are also seen cropping out at the lower part of the limestone cliffs on the opposite (southern) side of the river.

As the valley opens and the road enters the little flat of Damtour, limestones of triassic aspect come out from under the nummulitic ones, and form the face of the hill east of the village. Beneath these limestones are seen the Attock slates with a high easterly dip, and the lowest bed of the limestone series above, resting directly upon the slates, is a sandy conglomeratic one enclosing fragments of the underlying slate group, as observed in the Sirban mountain sections; but it is worth notice that the largely developed masses of red sandy or earthy ferruginous beds and greyer silicious dolomites representing the Infra-trias group of that adjacent mountain are here absent.

From Damtour onwards the road passes among and over the deep detrital deposits of the Abbottabad plain.

The mountains to the eastward repeat, with numerous disturbances and dislocations, the features of the Sirban mountain section, described in Memoirs Geological Survey, Vol. IX, Art. 3. The Spiti shales are locally more largely developed, and likewise fossiliferous *Belemnite* and *Ammonite*-bearing sandstones, which may be a portion of those referred to the Gieumal group. The Infra-trias cherty dolomites are largely present in the northern parts of these mountains, but appear to be capriciously distributed, sometimes alternating with sub-fossiliferous bands having entirely the triassic aspect, and in places occurring in some force before they rather suddenly disappear to the southwards. Their connexion with the Tanol group of Hazara is strongly suggested by the sections in the northern parts of these hills, and will be referred to in a separate note.

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Eight specimens of minerals and rocks (all metamorphic) from above 8,000 feet on the Safed Koh, near Gandamak.

MAJOR H. C. B. TANNER.

White quartzite, highest peak of the Safed Koh.
White marble from Safed Sang.
Soapstone, Terakai hill summit, above Murkekhel.

G. B. SCOTT, ESQ.

A collection of rock fragments and pebbles, many rolled and imperfect fossils, and small samples of soil from between the Khojah Pass and Sugari Barkhan. (See Pro. Asiatic Society, Bengal, June 1879.)

LIEUTENANT R. C. TEMPLE.

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